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AN INVESTIGATION INTO THE RELATIONSHIP OF THE INDUCTIVE COGNITIVE OPERATION AND MODES OF PRESENTATION

BY

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "An Investigation into the Relationship of the Inductive Cognitive Operation and Modes of Presentation" submitted by JOHN D. McRAE in partial fulfilment of the requirements for the degree of Master of Education.

ABSTRACT

Comprehension, or understanding of what is read, is an important aspect of the reading process. Researchers in comprehension increasingly look to the work of cognitive theories to help understand cognitive processes underlying comprehension skills. Several cognitive theorists suggest that the mode in which a task is presented may affect children's performance of cognitive operations.

The purpose of this study was to determine how well children at the grade four and grade six levels performed on tests of the inductive cognitive operation presented in a concrete mode, a pictorial mode and a written mode. The relationship of children's performance on these tests to selected variables was also determined.

The sample in this study consisted of sixty-four subjects from an Edmonton school: thirty-two from grade four and thirty-two from grade six with the boys and girls equally represented at each grade level. Subjects were selected on the basis of their reading achievement scores as measured by the Gates-MacGinitie Reading Test, Form D, and their I.Q. scores as determined by the Lorge-Thorndike Intelligence Test, Level 3.

Tests of the inductive cognitive operation were adapted or constructed especially for this study. Concrete objects, a series of pictures, and two written stories were used as materials for the tests. All tests were administered individually by the examiner. Data on the chronological age of the children were also collected.

Cont'd after "Acknowledgements"

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Data analysis entailed a three way analysis of variance with one factor repeated, Pearson product moment correlations and a stepwise regression analysis.

The findings showed that the mode of presentation (concrete, pictorial, written) influenced subject's performance of the inductive cognitive operation. Grade six girls performed significantly higher on the inductive reasoning test using concrete materials than in tests using written or pictorial material. Grade six boys performed significantly higher on the inductive reasoning tests using written and concrete material than on the tests using pictorial material. At grade four there was a steady but non-significant decrease in scores from concrete to picture to written tasks. Grade six scores were generally higher than that of the grade four scores but significantly so only for concrete tasks.

Very few significant correlations occurred between the variables chronological age, I.Q. reading achievement, sex and performances on the inductive reasoning tests. An analysis of the variance contributed by the different variables, showed that at grade four, sex contributed most of the variance of the concrete tests of induction while reading ability contributed most of the variance of the picture and written tests. For grade six students, the greatest source of the variance for the picture test was sex while the I.Q. variable contributed most of the variance of the concrete and written tests.

Educational implications and ideas for further research were also discussed.

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CHAPTER I

INTRODUCTION

> Educators have long said to themselves and to others that the proper business of school is to teach children to think. Yet this objective has remained a pious hope instead of becoming a tangible reality (Taba, 1965, p.543).

Although there is a certain amount of truth in the above statement, in recent years educators are attempting to make the objective, "teaching children to think", a reality. An article by Holmes (1964) suggests that current research in reading is characterized by a concern for the processes underlying the reading comprehension skills. Similarly, such educators as Spache (1968) and Russell (1967) have been expounding the importance of the cognitive domain and cognitive development.

I. THE PROBLEM

An interesting aspect of cognitive theories deals with modes of presentation and representation. The term "mode of presentation" refers to the stimulus object of a cognitive operation. The term "mode of representation" refers to the form which this object takes in the internal mental manipulations of the cognitive process.

According to Getzel (1964), Piaget and Bruner believe there is a developmental sequence of modes of representation. Both Piaget and Bruner posit three main stages in this sequence. In spite of their using different terms, and in spite of some conceptual differences, their stages are remarkably similar. Bruner referred to them as the

enactive mode, the ikonic mode and the symbolic mode. Piaget used the less descriptive terms, signal, symbol and sign. For both men the most important element of the final stage of development was language.

The similarity of these two views of the development of the modes of representation does not end with the comparability of the stages. Both Piaget and Bruner were careful to point out that even when an individual has acquired language, and therefore has attained the final stage in the development of the mode representation, he will continue to make use of the other two modes. Each mode has its peculiar advantage and depending on the particular content of the cognitive process, even the adult may make use of any of the three modes (Bruner, 1966, p.14). Moreover both men felt that the final mode of representation, particularly the verbal element, was the most difficult to use. Thus even at later stages of development, new cognitive processes will first be possible in an enactive mode. Only in the last stages of its development will this operation be possible in the more abstract verbal or lingual mode.

The mode of representation would appear to have a direct relationship to the mode of presentation. Voyat (1970) a former student of Piaget, gave a definition of reading which emphasized the influence of the mode of presentation (printed or written words) on the mode of representation.

> Reading is an abstract and representative activity. A word consists of a string of letters and as such does not carry any direct relationship with the object it designates (p.173).

The abstract mode of presentation forces the child to use an abstract form of representation.

It may well be, therefore, that for a child learning a new reading comprehension skill such as making inductive inferences his understanding of the task is complicated by the abstract mode of presentation which forces him into what may be a more difficult mode of representation.

The theories of Piaget and Bruner regarding modes of representation suggest to this writer a continuum of modes of representation moving from more concrete to more abstract. The more abstract the mode of representation the more difficult it is to use. Voyat (1970) suggested five stages in this continuum. Solomon (1970) spoke of five stages in what he saw as a concrete to abstract continuum. Solomon, however, felt that the continuum applied to modes of presentation also. The writer is in agreement with Solomon's views and thus arises the problem for this study. Rawson (1969) has indicated that children at a grade four level can perform certain cognitive operations more accurately when material is presented in a concrete mode rather than a written mode. This study will attempt to discover if a pictorial mode of presentation lies in the possible continuum between the concrete and written modes.

II. THE PURPOSE OF THE STUDY

This study is an extension of one portion of Rawson's (1969) work. One of the main purposes of her study was to ". . . explore the relationships between children's ability to reason logically concerning concrete experience and their ability to reason in reading (p.2)." Whereas Rawson was concerned with the five cognitive operations of

conservation, classification, induction, deduction and probability reasoning, this study will be limited to the inductive cognitive operation.

The purpose of this study will be to examine the relationship between grade four and grade six children's ability to reason inductively from material presented in concrete, pictorial and written modes. Moreover it will consider the effect on these relationships attributable to the sex and age of the subjects.

III. DEFINITION OF TERMS

Cognitive Operations

A cognitive operation is here defined as an intellectual process by which knowledge is gained about perception or ideas. This study will deal only with the overt expression of such an operation. The overt expression may be either verbal or motor.

Inductive Cognitive Operation

This is the intellectual process by which we proceed from the particular to the general. "From the fact that something is true of a certain number of members of a class we conclude that the same will be true of unknown members of the class also (von Wright, 1965, p.1)." For the purpose of this study, the inductive cognitive operation is defined in terms of the following four stages in a logical description of an inductive inference; recognition of an intervening constant, stating an hypothesis, verifying an hypothesis, and subsuming the evidence under a law. These four stages will be discussed in greater detail in Chapter III.

Mode of Presentation

This refers to the form in which material is presented to the subjects. This material becomes the object of an ensuing test of the inductive cognitive operations. In this study three such modes were used; concrete, pictorial, written.

Concrete Mode

This refers to a mode of presentation in which the stimuli are actual objects which the children can manipulate.

Concrete Test

This refers to the test of the inductive cognitive operation which has as its object, material presented in a concrete mode.

Pictorial Mode

This refers to a mode of presentation in which the stimuli are a series of photographs which go together to tell a story.

Pictorial Test

This refers to the test of the inductive cognitive operation which has as its object material presented in a pictorial mode.

Written Mode

This refers to a mode of presentation in which the stimuli are type-written stories.

Written Test

This refers to tests of the inductive cognitive operation which have as their object material presented in the pictorial mode.

Average Readers

For purposes of this study this refers to subjects who were within one standard deviation from the mean reading score of the Gates-MacGinitie Reading Test.

Average Intelligence

For purposes of this study this refers to subjects who were within one standard deviation of the score 100 on the Lorge-Thorndike Intelligence Test. For this test one standard deviation is sixteen I.Q. points from the mean.

IV. HYPOTHESES

The following hypotheses were tested in this study.

1. There will be no significant differences between performances on the concrete test, the picture test and the written test for either of the following groups (alpha $<.05$):

    a. grade four boys
    b. grade four girls
    c. grade six boys
    d. grade six girls

2. There will be no significant difference between the performances of grade four boys and grade four girls on (alpha $<.05$):

    a. concrete tests
    b. picture tests
    c. written tests

3. There will be no significant difference between performances of grade six boys and grade six girls on (alpha $<.05$):

    a. concrete tests
    b. picture tests
    c. written tests

4. There will be no significant difference between performances of grade four girls and grade six girls on (alpha $<$ .05):

   a. concrete tests
   b. picture tests
   c. written tests

5. There will be no significant difference between the performances of grade four boys and grade six boys on (alpha $<$ .05):

   a. concrete tests
   b. picture tests
   c. written tests

6. There will be no significant correlations between the tests of inductive operations and (alpha $<$ .05):

   a. reading ability
   b. sex
   c. chronological age
   d. I.Q.

An analysis will also be made of the performance of children on tests according to the sequence in which the tests were administered.

V. ASSUMPTIONS

The following assumptions have been made with regard to this study.

1. That the Intelligence and Reading tests administered several months prior to the study are still valid measures of intelligence and reading achievement.
2. That randomization of subjects into testing patterns will not bias any order of scores.
3. That the tests designed on the concrete, written and picture mode are valid tests of the inductive cognitive operation.

4. That the stories ("The Cave" and "The Ball") are of comparable difficulty.
5. That the sample is representative of the population from which it was chosen.

VI. LIMITATIONS

It is recognized that certain features may affect the data collected in the study. Some such features are:

1. The overt expressions, which will be used to assess the cognitive operations available may be influenced by what the subjects think they should be saying and cannot therefore be considered a perfect indicator of inductive reasoning ability.
2. Subjects chosen were within one standard deviation of the class mean and consequently generalizations would be restricted to students of similar reading ability.
3. With the exception of seven students, subjects were within one standard deviation of an I.Q. score of 100. Generalizations would be restricted to students of such an I.Q. level.
4. Subjects were selected from grades four and six. Consequently, generalizations would be restricted to students at these grade levels.

VII. SIGNIFICANCE OF THE STUDY

People such as Spache (1968) and Russell (1967) have indicated that cognitive operations are fundamental to reading comprehension. Comprehension is basically the application of thought to what is read.

Rawson (1969) has shown that cognitive processes are more readily available to children when material is presented in a concrete mode than when it is presented in an abstract mode. This would seem to imply that concrete materials may be used to develop the cognitive operations in children for reading purposes. However, concrete materials are not readily available. Moreover the gap between concrete material and abstract material (print) may be too great for adequate transfer to occur. If it could be shown that pictorial material formed an intermediary step between concrete and abstract material then the implication for using pictorial material to develop the cognitive operations would be considerable.

VIII. OVERVIEW

In Chapter II the writer will discuss Piaget's theory of cognitive development, on which this present study is based. In that chapter research related to this present study will also be reviewed. Chapter III will describe the design of the study while Chapter IV will be concerned with the statistical analysis of the data. The final Chapter will provide a summary of the findings, implications for the classroom teacher and suggestions for further research.

CHAPTER II

THEORETICAL BACKGROUND AND REVIEW OF THE LITERATURE

This chapter will contain three sections. The first will be concerned with the relationship of the cognitive processes to reading comprehension; the second will contain an overview of the work of Piaget on whose theory the cognitive operations in this study are based; the third section will review related research on cognitive operations and mode of material presentation.

I. COGNITIVE PROCESSES AND READING COMPREHENSION

Dechant (1970), in his book Improving the Teaching of Reading distinguishes between two types of emphasis desirable in reading instruction: one for the primary grades and one for grades beyond the primary. Implicit in this distinction is the recognition that reading is a composite of two broad types of skills. These may be referred to as the more mechanical decoding aspects on the one hand and the higher level comprehension aspects on the other. Probably the most common error made by the layman is to view reading instruction as being concerned solely with decoding. Typical of this misinterpretation is a statement made by Flesch in his 1955 publication Why Johnny Can't Read. "Teach the child what each letter stands for and he can read (p.2)."

The importance of understanding in reading instruction has long been recognized. As early as 1838 Mann decried the failure of teachers to pursue meaning (Stauffer, 1966). In 1908, Huey was calling for an

emphasis on what he referred to as "thought getting" (Huey, 1968, p.350). This concern has persisted until today when the concept of reading comprehension has become much more sophisticated. Smith (1963), typifies this new level of sophistication when she states:

> 'Comprehension' is just a big blanket term that covers a whole area of thought getting processes in reading. Teachers need to be more fully aware of the different mental processes involved in reading for meaning and developing all of them (p.257).

Two important developments in the concept of reading comprehension are implicit in the above statement. The first is the realization that there are specific comprehension skills. In the same book Smith devotes nearly 100 pages to a discussion of unique comprehension skills (pp.255-353). Dechant (1970), lists twenty-one separate comprehension skills, and goes on to discuss how to instruct pupils in these.

The second development implicit in the above statement is the growing concern and interest in the "mental processes" associated with these comprehension skills. In this regard Smith discusses work done by such people as Traxler (1938), Gans (1940), Gates (1949), Sochor (1952) and Guilford (1960) who examined the interrelationship of thinking and reading. This view of reading as being related to thought processes is described in the 1969 edition of The Encyclopedia of Educational Research.

> A second view of the reading process is that reading is essentially a process of meaning elaboration, or thinking in relation to symbols (Ebel, 1969, p.1075).

This statement is followed by a brief discussion of work by such men as Thorndike (1917), Harris (1948) and Gray and Rogers (1956).

Their work is described as being concerned with the ". . . cognitive processes that come into play above and beyond the basic perceptual processes in reading (p.1075)."

Perhaps a natural outcome of this interest in the processes underlying reading is the interest in other disciplines. In an article entitled "Contributions of Allied Fields to the Teaching of Reading", Spache (1968) made the following statement in connection with a discussion of research in cognitive development:

> Since comprehension is generally recognized as a cognitive or information-processing system, direct application of much of this research to the teaching of this process is possible (p.256).

Spache was particularly interested in Guilford's work. The latter (Guilford, 1966), in an article appearing in the February 1966 edition of the Reading Teacher, stated that he did not doubt that teachers of reading had many opportunities to teach children to think. Russell (1967), shared Spache's interest in cognitive theories but tended to be more eclectic. In an article entitled "Research on the Processes of Thinking With Some Applications to Reading" he presented a concise yet comprehensive overview of the research with a discussion of its relevance to reading.

Summary

It appears that the understanding of material read is a fundamental aim of reading instruction. The processes of understanding what is read are related to the more generic "cognitive processes or theories." In order to understand more fully these theories it is necessary to review the work of the cognitive theorists.

II. PIAGET'S THEORY OF COGNITIVE DEVELOPMENT

Spearman (1927) was one of the earlier advocates of the desirability of including cognitive processes as part of school instruction. In his publication The Abilities of Man he began by rejecting three prevailing doctrines of intelligence and substituting for these, three fundamental laws which could be used to describe all mental operations. Central to his model was his law of relations which stated ". . . when a person has in mind two or more ideas (using this word to embrace any item of mental content, whether perceived or thought of) he has more or less power to bring to mind any relations that hold between them (p.165)." This coupled with his third law which spoke of the ability to derive correlations, gave rise to what Spearman called the education of correlates and relations.

Using factoral analysis of tests of intellectual competence Guilford (1966), concluded that there were three factors of intellect which went together to form the "structure of intellect." The three factors were five operations, four contents and six products. Any intellectual function involved one of each factor, thus giving Guilford 120 distinct intellectual units which could be described in terms of operation, content and product.

Both these models have been useful to educators. Their prime insufficiency is that they are derived from the intellectual functioning of adults and therefore say little about intellectual development. Piaget was the first person not only to devise a meaningful way to describe cognitive functions but also to apply his method of descrip-

tion empirically by observing children from several age levels. In this way he structured a model of cognitive development. Since the late twenties Piaget has been recognized as the most prominent figure in cognitive development. In 1934 Vygotsky, who disagreed with Piaget on some basic points, said of him:

> It is not an exaggeration to say that he revolutionized the study of child language and thought. He developed the clinical method of exploring children's ideas which has since been widely used. He was the first to investigate child perception and logic systematically; moreover he brought to his subject a fresh approach of unusual amplitude and boldness (1962, p.9).

Piaget's model of cognitive development is by no means perfect. Baldwin (1927), points out the two areas of Piaget's work which have received the most serious criticism. He states that Piaget's empirical research has been ". . . badly controlled from the standpoint of experimental design and has been incompletely reported (p.297)." It would appear that any person who wishes to open up a new field as extensively as Piaget has done would necessarily go beyond the limits of standard experimental procedure. Moreover, as his work has been very extensive, it would seem difficult to say whether or not his report of it has been as complete as it should. It should perhaps be mentioned that Baldwin went on to say that in spite of these criticisms which he feels are serious, Piaget's contribution to developmental psychology has been enormous (p.298).

Piaget evolved a model of cognitive development consisting of four broad stages with distinct and describable characteristic cognitive functions. In order to understand more fully the meaning of these stages it is worth considering the principles Piaget sees operating at the various levels.

Piaget makes the basic assumption that if he sees a particular type of behaviour, he is able to infer that there must be some organizational properties of the intellect which determine this behaviour. The behaviour he refers to as the "content" and the organizational properties as the "structures". The question he then proceeds to answer is how do these structures arise, how do they function and how and why do they change (Le Francois, 1967). His approach to these questions is similar to the approach used by biologists in performing some of the fundamental tasks of their discipline. Piaget feels that in the development of any member of a biological genus we can see an interaction between internal factors and external factors.

> The result is that developmental theory necessarily calls upon the concept of equilibrium, since all behaviour tends toward assuring an equilibrium between internal and external factors, or, speaking more generally, between assimilation and accommodation (1968, p.103).

In other words Piaget sees cognitive development as a result of the adaptive mechanism of assimilation and accommodation. Piaget refers to these mechanisms as functional invariants; functions because they are the mechanisms of human intelligence and invariant because as functions they do not change throughout development (Le Francois, 1967).

In order to understand his concepts of assimilation, accommodation, equilibrium and hence adaptation it is necessary to consider first of all the organizational properties of the intellect, the structures. As stated before, these are the source and directing force behind the overt actions, the content. Structures and content may be combined to form what Piaget refers to as schema. A full understanding of schema is difficult to arrive at, for, as Flavell (1963) points out,

its definition grows over several volumes of Piaget's work. Flavell describes schema as:

> . . . a rich subtle notion full of shifting nuances and most thoroughly bound up with Piaget's whole conception of cognitive development (p.52).

By way of a preliminary definition of schema Flavell describes it as a cognitive structure which has reference to a class of similar action sequences. Although schema includes the internal structures it is named for the behavioural sequences associated with it. At an early stage of development the behaviours associated with a schema are external and we find such schemas as the schema of sucking. At later stages of development, actions, through symbolic representation become internalized and the behaviour of the schema is also internal as is the structure of the schema. At such a level the schema of intuitive qualitative response may be discovered.

Le Francois (1967), attempts to explain the nature of assimilation and accommodation as follows. The child is born with an ability to perform certain acts. This would, imply some cognitive structure. When the child reacts to a presented object he must do so in terms of this already established schema. Therefore if a toy is placed in his mouth he will suck it. In doing so Piaget would say that the toy has been assimilated to his sucking schema. This is an exercise of a pre-existant schema which remains essentially unchanged. However if an organism is to develop, the adaptive functions or mechanisms must allow for modification of the schema. This is the function of accommodation which may be illustrated in the following way.

As the child assimilates various objects to his sucking schema he will begin to change his pattern of sucking to suit the object. Gradually his schema will change to accommodate the new objects.

The equilibrium which Piaget spoke of in connection with the adaptation of the individual is really a balance between assimilation and accommodation. Too much assimilation leads to an unrealistic interpretation of reality as when a child at play utilizes a branch or a broomstick for a gun. In doing so the child is ignoring the "ungunlike" features of these implements. Too much accommodation leads to a meaningless interpretation of reality as the organism is adjusting structures before it has had sufficient experience (assimilation) with them. Piaget feels that development is governed by a need to arrive at a meaningful and realistic understanding of and ability to cope with the environment. Piaget stressed that the equilibrium of which he spoke did not consist of forces at rest. Rather it was a "dynamic" equilibrium. The maximum equilibrium will not be a state of rest but rather a maximum of activity on the part of the subject.

The motivation or drive which gives these mechanisms life is inherent in the schema. Piaget feels that there is an intrinsic need for the cognitive organs or structures, once generated to perpetuate themselves by more functioning. For example in his book The Origins of Intelligence, Piaget (1952), spoke of the schema of sucking in the following way.

> Now this schema, due to the fact that it lends itself to repetition and cumulative use is not limited to functioning under compulsion by a fixed excitant, internal or external but functions in a way for itself. The schema has an intrinsic need to assimilate (p.35).

Piaget, then has suggested a model for cognitive development. Based on the adaptive instinct of an organism which seeks equilibrium between assimilation and accommodation, he sees new and more complex structures being developed through the interaction of the organism and his environment. Each structure is founded on the structure that preceded it.

The Levels of Cognitive Development

Piaget maintains that every "normal" child will move through a definite sequence with each stage (Piaget hypothesizes four distinct stages) characterized by the appearance of a new structure. The goal of this development is what Piaget referred to as operations. It is helpful to have his concept of operations* in mind while considering the levels. Piaget defined an operation as follows:

> Psychologically operations are actions which are internalizable, reversible, and co-ordinated into systems characterized by laws which apply to the system as a whole. They are actions since they are carried out on objects before being performed on symbols. They are internalizable since they can also be carried out in thought without losing their original character of actions. They are reversible as against simple actions which are irreversible (Piaget, 1957, p.8).

Sensori-Motor Stage

This stage extends from birth to the acquisition of language. Piaget sees this period of infancy as being very important to intellectual development. He feels that the necessary processes of symbolic intelligence begin developing at birth (Phillips, 1969). The child is

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* The inductive cognitive operation is the main concern of this study.

born with certain reflex schema. As with all schema, it is in their nature to act and in so doing they are modified. Piaget referred to the infant's repetition of these actions as "circular reactions". By this he meant that the infant randomly instigates actions. If such actions are pleasurable they are repeated. In this way the infant gradually establishes a "repertoire" of sensori-motor schema. At first these are discreet but later become co-ordinated so that several can be sequentially ordered. At a certain stage the infant will be able to reach for an object, bring it to his mouth and suck it. Piaget distinguishes between thought, which he feels requires internalized actions, and intelligent actions. Thus a child who draws a coverlet towards him on which is resting a toy he wants is demonstrating an intelligent action but not thought. By the time the infant reaches the end of this stage he will have constructed categories of object, space, time and causality. In doing so he will have developed the interrelated concepts of reversibility and conservation. However as he is still limited in applying these overtly to actual objects they can by no means be considered operations.

As well as beginning the development of these two basic functions the child undergoes what Piaget aptly referred to as a "Coppernican Revolution". In the early part of this stage the child views everything in terms of himself. At this point he only assimilates. For example as he assimilates objects to his sucking schema the world becomes "something to be sucked". Gradually he begins to accommodate his schema and he comes to realize that he is part of a large world.

Preoperational Thought

This stage is distinguished by the appearance of the symbolic function. This function includes language, symbolic play, deferred imitation and internalized imitation.

> As a result of the symbolic function representation formation, that is to say internalization of actions into thoughts becomes possible (Piaget, 1957, p.11).

The achievement of the symbolic function has far reaching effects on cognitive development. The most powerful influence will come from the language factor. The child will now be able to begin to understand some of the thoughts of other people. Through language, thoughts can arise which are not exclusively related to the self generated acts. It should be noted that although Piaget sees the symbolic function as necessary for internalized thought, and sees language as the prime vehicle for this thought, he acknowledges the existence of pre-representational intelligent action. This in turn implies that prior to the acquisition of language the child does have intelligent structures. Language is gradually assimilated and the schema are accommodated to utilize it.

As language is assimilated it is first used as egocentric speech. For example, a group of young children at this stage will talk but their talk will be what Piaget termed a "collective monologue . . . a mutual excitation rather than an exchange of ideas". It is only later that social speech is achieved and finally hypothetico-deductive logic which applies thought to hypothetical statements.

Although Piaget sees the symbolic function as allowing for the internalization of action, the thought of the child at this level is

limited and cannot be considered as operational thought. One interesting feature of the thought at this level is that it loses the reversibility and conservation which were achieved at the end of the sensori-motor level. Although still able to use these two structures at a sensori-motor level he will be unable to use them internally until he reaches the next stage.

Thought at this level is also characterized by an intuitiveness. That is, the child makes assertions without relating them to facts. Piaget attributes this to a remaining vestige of egocentricity. What the individual thinks of, the individual accepts. If no questions are asked from the outside then there will be no effort to search for proofs. Intuitive thought lacks the ability to prolong actions already familiar to make them mobile and reversible. These primary intuitions are characterized by rigidity and irreversibility. Piaget compares them to perceptual schema such as hand writing which unfold in a definite sequence. With all its limitations, intuitive thinking is the highest form of equilibrium attained at this level.

Concrete Operations

This stage extends approximately from the age period of seven years to eleven years. Piaget (1957) describes this stage in the following way.

> The various types of thought activity which arose during the preceding period finally attain a state of mobile equilibrium, that is to say, they acquire the character of reversibility. In this way logical operations result from the co-ordination of the actions of combining, dissociating, ordering and setting up correspondences which then acquire the form of reversible systems (p.13).

Classification is one of the first important operational systems. The inclusion of classes is one type of classification which would permit the following operations: A+B'=B; B+B'=C where AxA'=0.

An example of this would be the following inclusive classification: Collies + non-collies dogs, (A+A'=B); dogs + non dogs animals, (B+B' C). Collies x non-collies (ie. the set that is both collie and non collie) = 0 (ie. is void).

Seriation, which Piaget refers to as the "linking of asymmetrical transitive relations into a system" is another of the systems acquired at this time. A task involving this system would be the arrangement of rods of unequal length in order from shortest to longest. Prior to achieving this level the child proceeds unsystematically by comparing AG, CD, EF, and corrects the result. After reaching this stage he will look for the smallest rod, then the smallest remaining rod and so on. This method presupposes the ability to co-ordinate two inverse relations. The child is in effect saying that the rod he selects next is smaller than all those not picked, yet is bigger than those picked.

The child at this stage is also able to classify objects according to two systems. For example, given the two sets of criteria, red - non red, and square - non square, he will be able to construct the four categories.

With the advent of the logic of classes and relations, the child will begin to see new aspects of reality. He will now begin to see rational relations between cause and effect. Where before he tended to offer egocentric explanations, such as the stars were born

because people were, he now attempts to explain things in less anthropomorphic terms. For example, his explanation of where the moon came from will be related to a cause whose explanation seems more readily available such as the clouds. Not much closer to the truth but at least indicative of a realization that the formation of the moon does have a relation to some other part of reality.

Although Piaget realized that there were limitations to how directly one could apply logic, still he felt;

> . . . that the language of mathematics and logic provide the vehicle with which to formulate the properties of concrete operations and make models of the organization and process of cognition (Stauffer, 1969, pp.389-390).*

Also appearing is a sense of atomism. He begins to see the world as being made up of indivisable particles. This was illustrated by Piaget with an experiment in which sugar lumps were dissolved in water. Although the lumps disappeared the child at this level maintains that they must still be present in some form in the liquid.

Although this level does see the appearance of reversible internalized actions there are two important restrictions. They remain insufficiently formal in that they are still related to the concrete field. That is, these operations develop separately field by field and result in a progressive structuralization of these fields without complete generalization being attained. For example, the child may develop conservation of weight, and still not be able to conserve volume or quantity. Secondly, although they are able to classify,

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* Rawson (1969) borrowed Piaget's technique for describing cognitive operations with symbolic logic. One of these operations (induction) was the focus of this study.

order serially and form equalities, these systems are not yet organized into structural wholes.

> Although concrete operations consist of organized systems (classifications, serial ordering, correspondences, etc.) they proceed from one partial link to the next in step-by-step fashion without relating each partial link to all the others. Formal operations differ in that all of the possible combinations are considered in each case. Consequently each partial link is grouped in relation to the whole; in other words, reasoning moves continually as a function of the structured whole (Inhelder, 1958, p.16).

Formal Operations

This stage begins approximately at the age of eleven years. Le Francois (1967) said of the period;

> The period is the culmination of an adaptive process which began at birth and which, through the processes of assimilation and accommodation has resulted in the development of intellectual structures which are theoretically as sufficient for understanding and coping with the environment as they ever will be (p.70).

The operations at this stage do not differ from those of the concrete level except in that how they may be applied to hypothetical statements. The possibility to accept any sort of data as purely hypothetical and reason from it correctly is now open to them. Piaget describes a problem which illustrates the difference in the approaches used by the children from the concrete level and the formal operations level. The children were given the following statement to criticize. "I am glad I do not like onions for if I did like them then I would be eating them all the time and I hate eating unpleasant things." The criticism of the child at the concrete level might be a statement to the effect that it is wrong not to like onions. At the formal level the child would simply point out the contradiction between ". . . if I

did like them . . ." and ". . . unpleasant things . . ." (Piaget, 1957). Now, rather than simply co-ordinating facts about the world, the child is able to extract principle from hypotheses, thus permitting the construction of structured wholes. This, in turn, allows exploration of concepts which are beyond empirical experiment.

Piaget describes two other important changes which occur at this time. These changes are marked by the appearance of two new operational schema apparently unrelated to the logic of propositions. The first is combinatorial operations which are necessary for combinations, permutations and aggregations. It is these operations which allow a child to combine a given number of counters into all possible combinations. The second is proportional operations. These will allow the child to discover proportions in motion, geometry, distance and weight.

In short, with the advent of the formal co-ordinated logic of propositions and the new operational schema, the final period of development is reached.

Vertical and Horizontal Decalage

The stages of development reviewed above reveal a development along a continuum from concrete to abstract. This development, which Piaget referred to as vertical decalage, is not linear in the sense that a structure must have achieved full equilibrium before structures which follow in the sequence have begun to develop. Thus it is possible to see within a child two or more structures developing simultaneously, with the earlier structures being more developed than the more recent. For example a child at the conclusion of the sensori-motor stage will

have achieved reversibility. However when he acquires the symbolic function, he must return to much simpler uses of this new structure and will not be able to apply it to reversals until the next stage, concrete operations (Piaget, 1957).

This decalage within stages was discussed in an article by Beilen (1968). He distinguished between unitary theories of development which see cognitive stages being reached in all areas at once, and non-unitary theories which allow the stage to be reached but not necessarily in all areas. Research had led him to conclude that although a non-unitary theory was favoured the results were not unequivocal.

It seems that vertical and horizontal decalage are related to the concepts of representation and presentation. That is, the cognitive operation (at a particular stage) is influenced by the mode or manner in which the problem is presented. Solomon (1970) states that:

> The developmental levels of Piaget proceeding from the sensorimotor to the stage of formal operations, and those of Bruner proceeding from enactive to symbolic have this in common; they both suggest a concrete to abstract continuum (p.53).

Solomon (1970) suggests that this continuum exists not only as the child progresses from stage to stage but also horizontally within stages. He further suggests the intermediary and necessary step between the concrete and the abstract involves pictorial images. It was the aim of this study to seek further information on this particular hypothesis.

Summary

Piaget was the first to apply a description of cognitive operations by empirically observing children of various ages. Thus he was the first to study cognitive development. Piaget viewed development as a biological adaptive process which sees the organism striving to achieve an equilibrium between internal and external factors. This equilibrium sees the organism assimilating external factors to his established thought pattern (structure) and action patterns (content). Content and structure he collectively referred to as schema. The process of assimilation may in turn cause a change in the schema to accommodate the external factor assimilated.

Piaget felt that as a result of this adaptive process, a person would pass through a definite sequence of cognitive styles as he developed from infancy to adulthood. He identified four broad stages in this development. Each of these stages is marked by the appearance of a new structure. A child in the first stage, sensori-motor is limited to overt intellectual action. With the second stage, preoperational, the child acquires the symbolic function and is thus able to internalize his "intellectual actions". The third stage, concrete operations, sees the child capable of reversal and conservation with his "internalized actions". Formal operations, the final level, is characterized by the ability to reason with purely hypothetical material.

A child's mode of operation, however, is dependent upon the material in which the problem is presented. That is, at a particular stage, a child able to perform a certain operation when materials are

presented in concrete form, may not necessarily be able to solve the same problem when it is presented in a more abstract mode (print).

III. COGNITIVE OPERATIONS AND MODE OF PRESENTATION

Inhelder (1958) was aware of the change in the nature of the problem when material was changed from a concrete form to a verbal form. She states:

> When verbal statements are substituted for objects, a new type of thinking - propositional - logic - is imposed on the logic of classes and relations relevant to these objects (p.253).

She made this statement after a discussion of two problems of seriation. The first one required the child to put several sticks together in order of the length. She reported that children age seven were able to do this. Continuing, she stated that this problem involves the same logical operations required to solve such a problem as "Edith is lighter than Suzanne and Edith is darker than Lily; which is the darkest of the three (p.252)?" This problem, she reported, cannot be solved until age eleven or twelve because of the more abstract form in which it is presented.

A study by Beilen, Kagan, and Rabinowitz (1968) involved 180 subjects with a mean chronological age of seven years six months who were split into nine heterogeneously grouped classes with no significant differences in I.Q., S.E.S. or chronological age. The purpose of their study was to determine whether language and perceptual experience can play a significant role in the child's manipulation of symbolic images. The pre-test and post-test were adapted from the work of Piaget and Inhelder. A large jar partially filled with a red coloured liquid was

used in the pre-test. This was covered in such a way that shape of the jar was visible but the liquid was not. The jar was rotated through various angles. For each position of the jar, the children were supplied with a choice of eight diagrams of water levels from which they were requested to select the diagram which represented the correct water level. This test was also used as a post-test, plus a transfer test which followed the same procedure, but used a 1000 ml. florence flask. On the basis of the pre-test findings, the experimenters excluded from their study those children who were able to predict the water level. Following the pre-test, three classes received verbal training, three received perceptual training and three received no training (control group). The verbal session made use of words and pictures, while the perceptual method simply repeated the pre-test situation but the cover of the jar was removed after each repositioning. The post-test and transfer test revealed that although on the pre-test there was no significant difference between the means of the various groups on both final tests the perceptual group performed significantly better. Both groups did better than the control group which received no training.

It should be noted that the training moved these children from one stage of cognitive development to another and that the less abstract mode, ie. perceptual, was more successful in accomplishing this result.

This study, however, emphasizes one of the main problems with research in this area. In evaluating the efficiency of one mode over another it is important to keep in mind the purpose for which the training is being given. In this study training was provided for visual

imagery, as measured by a perceptual test, and it would heuristically be expected that perceptual training would best prepare the subject. In a 1968 study, Wohlwill (1968) demonstrated that, for class inclusion questions, a verbal test would always allow for higher performance than a pictorial one. His study consisted of three experiments. In each the subjects completed pre-tests and post-tests in both pictorial and verbal form. In every case, whether the subjects had received verbal or pictorial training, they all performed significantly better on the verbal post-tests. Wohlwill's explanation was that the pictorial test form created a strong tendency in the subjects to translate a class inclusion question into a sub-class comparison question which thus interfered with the correct verbal response.

Sullivan (1967) examined two different modes for training the cognitive operation of conservation. Both modes consisted of the same visual portion of a film of two men pouring equal amounts of orange juice from identical containers into two containers of different diameter. One visual portion, however, was accompanied by a careful explanation of the principles to illustrate that there was no liquid removed or added while the audio portion of the other film was ordinary talk without specific reference to the action being demonstrated. There was no significant difference in the two groups on post-tests of conservation, tests of transfer of conservation, or tests of extinction of conservation. However, the verbal group performed significantly better ($p < .005$) on a task requiring explanations.

Butters (1968) carried out a study in which both pre-test and post-test were verbal. He was comparing the effectiveness of a verbal,

a perceptual, and a functional training procedure for training children in grade one in equivalences. Responses of the children were judged on two sets of criteria. The semantic criteria determined if equivalences were perceptually based, functionally based, nominally based or affectively based. The syntactic criteria determined if their classification had been superordinate or complexive. He found that the children who had been trained verbally showed a significant increase in functional responses ($p < .01$) and a significant decrease in perceptual response ($p < .05$). However, even though the test was in a verbal form the verbally trained subjects made no increase in superordinate responses, whereas the pictorially and functionally trained groups made a significant increase ($p < .025$) in these.

In 1969, Rawson conducted a study - the purpose of which was stated as follows:

> The purpose of this study is to explore the relation between children's ability to reason logically concerning concrete experiences and their ability to reason in reading: and to consider the role of reading in the on-going intellectual development of nine- and ten-year-old children (p.2).

She cited work of Bruner and Greenfield which indicated that children from primitive societies who had had no schooling had made little cognitive development beyond the age of nine (p.6). On the hypothesis that it was the reading aspect of schooling which accounted for this lack of development, she designed a series of tests which would not only allow her to generate statistics regarding the relation of concrete performance to reading performance but would also allow her to make inferences as to the effect of reading upon general cognitive development. Concrete tests and reading tests were designed to assess

the five cognitive operations of conservation, classification, induction, deduction, and probability reasoning. The concrete tests were adapted from the work of Piaget and Inhelder. She designed the story tests herself.

The sample consisted of fifty boys and fifty girls randomly selected from a population of 514 grade four children. Their ages ranged from eight years seven months to nine years eight months. They had an average I.Q. of 109.7 and all but sixteen had been reading at grade level or beyond when they had been tested the year prior to the study.

Among the findings of Rawson's (1969) study are the following:

1. In all cases the subjects did better in the concrete situations.
2. Although sex was not a significant factor in either the reading achievement test or the story tests of the various cognitive operations, it was significant in several of the concrete tests. That is, in solving problems based on concrete objects, the boys tended to do better than the girls.
3. When correlations were computed between story tests and concrete tests in a single cognitive operation (eg. concrete induction to story induction) findings revealed that only conservation and deduction ($p < .01$) were significantly related. From this Rawson concluded that, with the exception of conservation and deduction, problems involving identical logical operations could be of different difficulty when presented in a story situation or a concrete situation.

Of particular relevance to this present study are Rawson's findings regarding the inductive cognitive operation. Examination of the mean per cent correct for the two test situations reveals that induction had the lowest overall performance. This would suggest that of the five operations which Rawson examined, induction is the least developed at this stage (grade four).

Summary

The studies reviewed in the above section indicate that the mode in which problem tasks are presented influences the child's response to the particular tasks. Since most of the studies reviewed above were concerned with training in the various cognitive operations it is difficult to draw conclusions regarding the difficulty of pictures as compared with the difficulty of concrete and abstract (written) material. As indicated earlier, Solomon (1970) believed that pictorial images represented an intermediary step between concrete and abstract material. With this point in mind it was hypothesized in this study that intermediate grade pupils would perform best on the concrete test, less well on the picture test and least well on the written tests when presented with questions of inductive reasoning. In keeping with Piaget's stages of cognitive development it was also expected that grade six students would perform significantly higher than the grade four pupils on the various tests.

CHAPTER III

THE EXPERIMENTAL DESIGN

This chapter contains a description of the design of the study, the subjects who participated in the experiment, the data relevant to the study, the collection of the data, and the statistical treatment.

I. THE DESIGN OF THE STUDY

The main purpose of this study was to investigate the effect the mode of presentation would have on the inductive cognitive operation. A two by two by three factorial design with the last factor repeated was used. As well as the variables of grade, sex, and inductive test scores which were used in the central design, those of age, I.Q., and Reading level were also considered.

Computation of analysis of variance and correlations were the main statistical procedures used. The transfer effect from picture to written tests was also considered.

II. SAMPLE SELECTION

The population for this study consisted of all children enrolled in grades four and six in one school of the Edmonton Separate School System. There were ninety-five pupils in grade four and ninety-four pupils in grade six. Grade four was selected as this was the level used by Rawson (1969) in her study and it was hoped that comparisons might be drawn between the results of both studies. Grade six was

selected in order to determine whether there was any development of the inductive cognitive operation over the two year period. Since the average chronological age of the grade six pupils was eleven years eight months (approximately the beginning of Piaget's stage of formal operations), a change in performance from grade four to grade six was expected.

Sixteen boys and sixteen girls were selected from each of grade four and grade six according to the following criteria.

The main criterion was to select children who were fairly homogeneous in reading achievement. All children in the test population had been given the Gates-MacGinitie Reading Test, Form MI in January, 1971, and the thirty-two children from each grade were selected from those who fell within one standard deviation of the mean score of the Comprehension subsection of that test. The mean reading scores of the pupils selected for this study are given in Table I. It will be noted that the mean scores of the grade six boys is higher than that of the grade six girls and the difference was statistically significant at the .01 level of confidence. Although the total grade six sample was within one standard deviation of the mean for this grade, apparently the girls scores fell in the upper portion and thus the difference noted above, resulted.

From those children whose reading scores fell within one standard deviation of the grade mean, an attempt was made to select for the sample those whose I.Q. scores were within one standard deviation of the Lorge-Thorndike Intelligence Test. All children at each grade level had been given this test in September, 1970. However, selection

on this basis was not entirely possible and seven pupils whose scores were above the sixteen point boundary were chosen.

Although it had been planned to omit any children who had repeated a grade, it was later realized that two male subjects in grade six were repeaters. Their data were analysed as part of the sample.

TABLE I

MEAN AGE, I.Q., AND READING LEVEL OF THE TEST SAMPLE

	Age	I.Q.	Reading Grade
Grade Four Girls	9-10	105.4	5.1
Grade Four Boys	9-10	103.3	5.1
Grade Six Girls	11-7	105.1	6.6
Grade Six Boys	11-10	109.2	7.3

III. TEST INSTRUMENTS

Lorge-Thorndike Intelligence Test, Level 3

This is a group intelligence test consisting of two sub-tests. These sub-tests give a verbal and nonverbal measure of intelligence. Freeman (1959), states that this test ". . . is among the best group tests available from the point of view of the psychological constructs upon which it is based and statistical standardization (p.479)."

Gates-MacGinitie Reading Tests, Survey D.

This reading test contains the three following sub-tests; (1) Speed and Accuracy, which provides an objective measure of how well

pupils can read with understanding, (2)Vocabulary, which samples the students reading vocabularies, (3) Comprehension, which measures the pupils' ability to read complete prose passages with understanding. The Gates-MacGinitie is a recent revised version of Gates Survey Reading Test. Although The Buros Mental Measurements Year-Book does not yet have a review of the Gates-MacGinitie, the 1965 edition contains the following comment by Spache regarding the Gates Survey Test.

> Despite the many minor limitations, this test will probably continue to find wide and profitable use in survey testing and in evaluation of reading programs and of school systems even though it lacks diagnostic features and may lack close relationship to teacher's estimates (p.1065).

Tests of Inductive Reasoning

Tests were especially designed or adapted for this study to test inductive reasoning. Questions requiring this cognitive operation were based on material presented in a concrete mode, pictorial mode, and written mode. Each test will be discussed below in terms of the materials used, test questions, validity, and reliability.

Concrete Materials

The apparatus used was originally designed by Inhelder (1958, p.94), later adapted by Rawson (1969, p.198), and has again been adapted for this study. A spinner was mounted in the center of a circular sheet of plywood. The circle had been divided into six equal portions, each portion a different colour. Placed around the spinner in these portions were six blocks of wood. Although all blocks were identical in size and colour they were of three different weights. The subjects could thus discern two heavy blocks, two medium weight blocks

and two light blocks. Concealed in one of the heaviest blocks was a magnet. The spinner had metal concealed in one end. When the subject spun the spinner it would stop at the block with the concealed magnet.

Pictorial Materials

These materials consisted of thirteen 3x4½ black and white photographs mounted on a sheet of cardboard. The series of photographs formed a story, much like a comic strip without words.

Written Materials

There were two different stories used. One, ("The Cave" - and hereafter called Story 2) was taken directly from Rawson's study. The other, ("The Ball" - and hereafter referred to as Story 1) was designed by the present writer and had the same content as the story told by the pictures. Both stories were subjected to the Dale-Chall Readability Formula and were found to be at a grade 4.6 level of reading difficulty. Since the average reading grade four sample was 5.1, it was assumed that reading achievement would not be a factor in test performances.

Test Questions

Questions for the concrete test and one of the story tests were taken directly from Rawson's work. Questions for the other story test and the picture test were modeled after these. In order to understand fully the nature of the questions designed to elicit the inductive cognitive operation, it is necessary to describe the steps within this process. The questions themselves and the scoring criterion are found in Appendix B.

Steps in the Inductive Cognitive Operation

Using Bocheski's description of the processes of inductive reasoning, Rawson (1969, pp.193-206) indicated that inductive test questions must go through the following four stages.

1. Recognition of an Intervening Constant. A distinguishing feature of inductive reasoning is the need to recognize that a new situation exists. Therefore, the first question in both tests requires that the children recognize the presence of an intervening contrast.

2. Statement of Hypotheses. Rawson distinguished between classificatory hypotheses and hypotheses which could be considered propositional. A classificatory hypothesis required that the child state what the actual cause of the activity was. For example in the concrete tests, the spinner stopped at a certain point because of a magnet in a block and a propositional hypothesis would require the child to consider the state of affairs in terms of the compatibility of propositions. He might state, "It is possible that A and B are magnets, or that A is a magnet and B is not."

However, Rawson found this distinction too difficult for scoring purposes and therefore established her question criterion as follows:

> The hypothesis (classificatory or propositional) must be intended to account for more than one protocol statement at a time, and recognition of its limitations must be indicated (Rawson, 1969, p.204).

This criterion was used for the construction of the second question in the tests of this study.

3. Verification. Verification may proceed either by falsification or confirmation. That is, the child must be able to prove that the hypothesis he posited on the basis of question two was either true (verification) or false.

4. Subsume the Evidence Under a Law. The fourth question required the subject to make a correct inference which would account for all significant changes in the story.

IV. CONSTRUCT VALIDITY OF TESTS

The construction of the concrete, picture, and the story tests was based on seven rules proposed by Smedslund for the testing of cognitive operations in a concrete situation. Rawson applied these rules as far as it was possible in the construction of her tests.

Rule 1. The tasks should not be solvable on the basis of perceptual processes. This can be assumed if the initial events are absent at the moment of solution.

In her concrete tests of induction this was not followed and will not be followed in the present study. However, both pictures and stories were removed when the children were answering the inductive questions.

Rule 2. The tasks should not be solvable on the basis of readily available hypotheses with a non logical structure.

Questions for the induction test required pupils to establish premises and necessary conditions. No test could be completed solely on the basis of experience.

Rule 3. The possibility of being correct by guessing should be minimized . . .

This criterion was met by requiring all but one question to be accompanied by some form of explanation. The subjects were able to get credit for recognizing that there was an intervening constant in the concrete test on induction even if they were unable to answer any further questions.

Rule 4. All information available to the subject should be in the form of perceived events. Verbally communicated hypothetical premises should be avoided.

Care was taken in all three test situations to avoid telling the subjects the answer to any questions. If they failed to notice necessary pieces of information, they were referred back to the part of the story or picture and were guided by questioning until they verbalized their perception. This procedure was also used to meet the criterion of the fifth rule.

Rule 5. It must be perceived that the subject perceives the relevant events.

Rule 6. There should be no differential reinforcement during the test. Every response should get the same mild positive reinforcement.

This was kept in mind during the testing. During introductory sessions with the subjects every effort was made to impress upon them that this was a test of how children reasoned, and was in no way affecting their school grading. It was hoped that this would make them more inclined to express themselves freely. During the test situation

all statements were accepted by the examiner without negative feedback and the subjects were encouraged to explain their conclusions.

Rule 7. The same type of material should be used throughout the items as far as possible in order to keep constant any effects the type of material may have.

Three types of material were used in this study; concrete objects, pictures, and printed materials. However, the complete cognitive operation (see Steps in the Inductive Cognitive Question, pp.43-44) was completed in response to each set of materials. Furthermore, the four questions on all three modes of presentation were patterned on the same principles.*

V. CONTENT VALIDITY OF TEST ITEMS

The questions designed to elicit the inductive cognitive operation were carefully based on the four steps within this operation as set forth by Rawson (1969).

The tests were administered to a group of children in grades four and six during a pilot study and some changes were made on the basis of the results. The questions were later submitted to several adults who answered each question in terms of the four steps mentioned above. Thus, the experimenter felt satisfied that the questions were eliciting the inductive cognitive operation.

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* The logical comparability of these three sets of tests is given in Appendix C.

VI. RELIABILITY OF THE TESTS

Since two of the test situations were taken directly from Rawson's study (and the other two were closely modeled after these) her reliability data are given. Rawson estimated the reliability of her concrete and stories tests by the test retest method. A two week interval was allowed between tests. The results are given in the following table.

TABLE II

MEANS, STANDARD DEVIATIONS AND TEST-RETEST RELIABILITY COEFFICIENTS FOR TOTAL SCORES ON CONCRETE AND STORY TESTS.

Tests	X_I	SD_I	X_{II}	SD_{II}	n-1	r_{xx}
Concrete	44.25	7.03	46.67	5.85	12	.74
Story	30.00	7.67	30.92	7.93	12	.72

(Rawson, 1969, p.91)

On the basis of the data, it was assumed that the tests would be sufficiently reliable.

VII. TEST ADMINISTRATION

All subjects were tested individually by the experimenter. Each subject received the same inductive test on material presented in a concrete mode and the pictorial mode.

There were two different sets of written material (stories). The content of one was identical to the pictorial material whereas the other was taken from Rawson's study. One half the subjects in each of the four groups (boys and girls in grades four and six) received each story by a random procedure.

There were twelve possible orderings of the presentation of the tests. Two subjects per grade were randomly assigned to one of ten orderings while six subjects per grade were randomly assigned to each of the remaining two orderings. These latter two orderings were: Picture - Story 1 - Concrete, and Picture - Story 2 - Concrete. The data from these orderings were used to determine whether any transfer had occurred from picture to story tasks.

Subjects were given the Concrete tests and immediately asked the five questions.*

When the picture and story tests were given, the subjects were first required to note certain aspects regarding the content of each situation (in keeping with Smedlund's Rule 7, page 42). The test questions were then asked. Depending on the responses elicited, certain procedures were adopted. These procedures are given with the questions in Appendix B.

A tape recorder was used to record all protocols.

VIII. SCORING THE TESTS

Each question was valued at one point. The nature of the responses accepted is outlined in Appendix D.

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* See Appendix B

IX. RELIABILITY OF SCORING THE TESTS

Four protocols* (two from each of grade four and six) were randomly drawn and submitted to a university professor for scoring. Both scorers were in perfect agreement on the scoring.

It was assumed that the method of scoring was sufficiently reliable. All the tests were scored by the experimenter.

X. TREATMENT OF THE DATA

The following statistical analyses used were programmed for use on the I.B.M. 7040 at the University of Alberta.

Three Way Analysis of Variance With One Factor Repeated (ANOV 30)

A factorial experiment permits the evaluation of the combined effect of two or more variables and the evaluation of an interaction effect (Winer, 1962, p.140). The diagram below indicates the components of the three factors.

TABLE III

FACTOR AND LEVEL COMPONENTS IN THE THREE WAY ANALYSIS OF VARIANCE WITH ONE FACTOR REPEATED

factor A grade	factor B sex	factor C tests of induction
Grade Four	girls	Concrete Picture Written
	boys	
Grade Six	girls	
	boys	

* See Appendix D

Although factor C did not involve the identical test being given three times, it has been demonstrated that the three tests involved the same logical operations. Therefore, it was felt that this analysis was appropriate.

Tests for Simple Main Effects (APL Function and ANOV 14)

This was used to discover the source of the main effects indicated by the previous analysis.

Newman-Keuls Test

In cases where significant main effects involved more than two variables this test was used to check for significant differences between all the means. This is the procedure recommended by Winer for use in connection with a repeated measure factorial experiment (Winer, 1962, p.309).

Pearson Product Moment Correlation (DEST 02)

Matrices were computed using all data from both grades, and then using data from each grade separately. It was hoped these correlations could be used to help give further information concerning previous analyses and that they might reveal relationships not apparent in the analyses of variance.

Test for Transfer

One of the transfer formulae discussed by Murdoch (1957) was applied to discover any differential transfer effect of picture test to a following written test, attributable to the similarity or dissimilarity of contents.

XI. SUMMARY

From a population of grades four and six a sample of sixteen boys and girls from each grade level was chosen in terms of their reading achievement and I.Q. scores. Concrete, picture and written tests of the inductive cognitive operation were administered to individual subjects by the examiner. The inductive questions were designed to elicit four distinct types of operations characteristic of the logic of inductive reasoning. The data were then submitted to statistical analysis in order to determine the effect of mode of presentation on the inductive cognitive operation.

In the following chapter the results of this statistical analysis will be discussed.

CHAPTER IV

ANALYSIS OF THE DATA AND FINDINGS OF THE STUDY

The purpose of this chapter is to present the analysis of the data and findings of the study under the following headings.

1. Performances of the grade four and six subjects on the three forms of the inductive tests.
2. Analysis of variance of subjects on tests of induction.
3. Correlational analysis of selected variables.
4. Stepwise regression analysis using inductive test scores as the criterion variables.
5. Transfer from picture tests to story tests.

I. PERFORMANCE OF THE GRADE FOUR AND GRADE SIX SUBJECTS ON THE THREE INDUCTIVE TESTS

The subject's scores were converted to percentages. Table IV contains the mean percent scores of all subjects as well as the standard deviations for scores on each test.

Three of the four groups were most successful with questions presented on tasks in the concrete mode. Boys attained higher scores than girls on tasks presented in the written mode (stories). Performance by sex on the other two tasks was inconsistent. That is, at the grade four level, boys scored higher than the girls on questions based on concrete objects and pictures. Results were reversed for the sexes at the grade six level.

TABLE IV

MEAN PERCENT SCORES AND STANDARD DEVIATIONS OF THESE SCORES ON THE THREE INDUCTIVE TESTS

Groups	Tests					
	Concrete Test		Picture Test		Written Test	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Grade Four Girls	38.44	27.31	37.50	25.82	32.81	26.95
Grade Four Boys	47.50	25.17	46.87	32.75	48.31	32.34
Grade Six Girls	75.00	22.50	37.50	25.82	34.38	27.20
Grade Six Boys	67.50	30.00	31.25	19.36	57.81	35.02

An interesting finding from the data is the difference between scores on the three tasks for grade four students in contrast with such differences for the grade six students. The means were almost identical on all three tasks for the grade four students, whereas the grade six students scored very high on the concrete tests, they scored lower than the grade fours on the picture tests, and then increased their scores on the written tests to a few points above the grade four mean. Thus it would appear that whereas grade four students found the tests more difficult according as tasks were presented on concrete - picture - story form (as was predicted), grade six students were much more erratic in their performance.

It also appears from the data that although the grade six students of this sample had a mean chronological age of eleven years

eight months, they were not any more successful than the grade four pupils in carrying out the inductive cognitive operation on problems presented in the more abstract forms of pictures and stories. This statement, however, is only partially true. Figures in Table IV show that the grade six boys performed very well on the written tests. The fact that the grade six boys had obtained significantly higher scores on the reading achievement test (Table I, Chapter III) may have had some bearing on the result. The different performance patterns by grade are highlighted in Figure I.

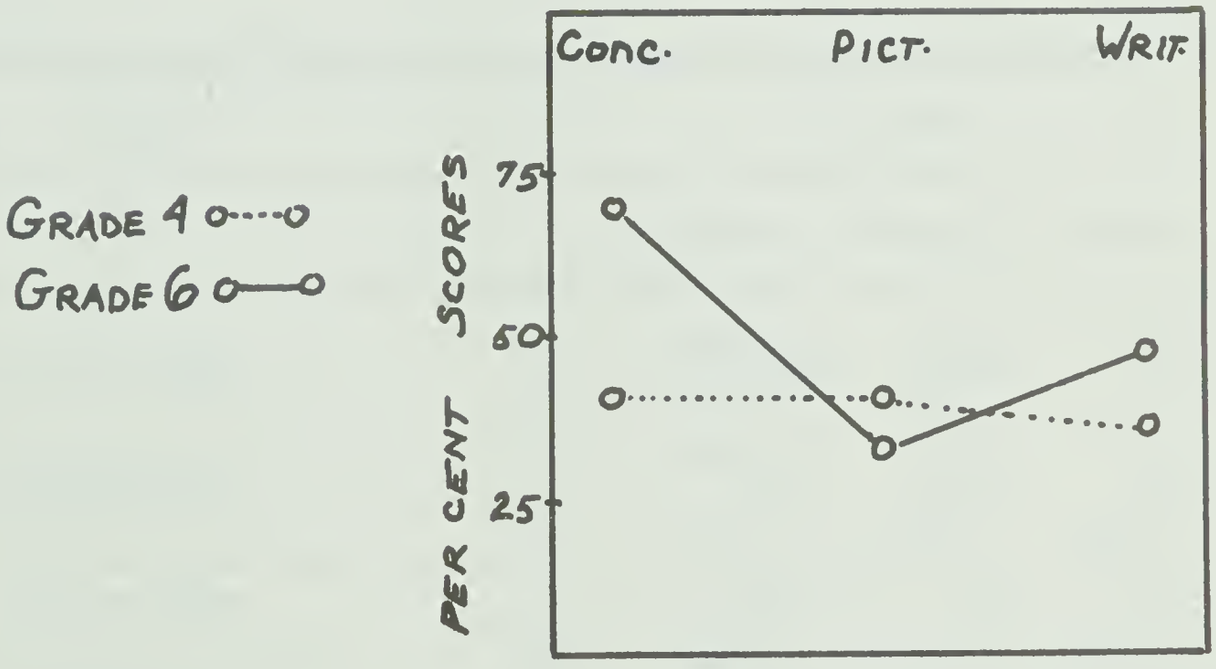

Figure 1

Performance Patterns by Grade

One reason for this diversity of scores may be the apparent improvement of grade six pupils to reason inductively about tasks presented in a concrete situation. Although the grade six pupils performed higher on the written task (as was expected) they scored lower than the grade four pupils on the picture task. This would also account for the discrepancy of scores among tasks at the grade six level.

To discover the significance of differences by task between grades and sex an A.P.L. function was used. The results of this analysis appear in Table V.

TABLE V

MAIN EFFECT OF SEX AND GRADE ON PERFORMANCES IN THE THREE TEST MODES

Effects		Tests		
		Concrete	Picture	Written
Gr. Four Girls vs.	M.S	10694.53	0.00	19.53
Gr. Six Girls	F	13.79**	0.00	.03
Gr. Four Boys vs.	M.S	3200.00	1953.13	722.00
Gr. Six Boys	F	4.13*	2.52	.93
Gr. Four Girls vs.	M.S	657.03	703.12	1922.00
Gr. Four Boys	F	.85	.91	2.48
Gr. Six Girls vs.	M.S	450.00	312.51	4394.53
Gr. Six Boys	F	.58	.40	5.67*

Significant at the .01 level**
Significant at the .05 level*

According to the data of Table V, there are only three significant differences between the various groups on tests of inductive reasoning. Grade four girls and grade six girls differed on the concrete tests at the .01 level of significance. Grade four boys and grade six boys differed on the same tests but at the .05 level of significance. In each case the pupils at the grade six level obtained the higher scores (Table IV). Girls and boys at the grade six level differed significantly on their performance of the written test of induction with the boys obtaining higher scores than the girls. Although grade four boys obtained higher mean scores than grade four girls on all tests (Table V) the differences between the sexes did not reach statistical significance ($p < .05$).

Summary

Boys and girls at both grade levels tended to score higher on the concrete tests of induction than on tests presented in picture and written materials. Grade six boys and girls scored significantly higher on concrete tests of induction than their corresponding counterparts at the grade four level. The only difference between sexes within grades occurred at the grade six level where boys scored significantly higher than the girls on the written tests.

II. ANALYSIS OF VARIANCE

To determine whether any significant differences among scores on the various tasks occurred within the groups, the data were subjected to a two by two by three factorial experiment with one measure repeated using an ANOV 30 program. A summary of that analysis is seen in Table VI.

TABLE VI

SUMMARY OF ANALYSIS OF VARIANCE BY GRADE
SEX AND THREE TEST MODES

Source of Variance	S.S.	df	M.S.	F	P
Between Subjects	80603.00	63.00			
Grade	3605.31	1.00	3605.31	2.94	.09
Sex	2537.50	1.00	2537.50	2.07	.16
Grade x Sex	783.81	1.00	783.81	.64	.43
Subjects Within Group	73676.38	60.00			
Within Subjects	93836.00	128.00			
Test Mode	12157.50	2.00	6078.75	11.07	.00**
Grade x Mode	10658.20	2.00	5329.12	9.70	.00**
Sex x Mode	5376.06	2.00	1788.03	3.26	.04*
Grade x Sex x Mode	1541.81	2.00	770.91	1.40	.25
Mode x Subjects Within Group	69023.75	120.00			

Significant at the .01 level**
Significant at the .05 level*

An analysis of the data of this table indicates that the performance of subjects depends on the material in which the inductive operation problem is presented, that is, on the mode of presentation. There is no main effect due to grade or sex. However, the significant interactions between grade X mode and sex X mode indicates that although there is no consistent effect on test performance attributable to sex

or grade, specific test performances will be affected by sex or grade. This interaction will be discussed later in this section.

Test Effect

In order to determine the source of the test effect a one way analysis of variance was carried out for grades and sexes separately. The results of that analysis appear in Table VII.

According to the data of Table VII, the grade four students do not differ significantly in their performance of tests presented in the different modes. It was shown previously in Table IV that the means for grade four pupils were very similar across the three tests. Grade six pupils did differ significantly at the .01 level on the three sets of test scores. Girls as a group also differed on their responses to the three test situations. Differences on the boys scores reached the .05 level of significance.

TABLE VII

ONE WAY ANALYSIS OF VARIANCE OF TEST EFFECT
WITH SUBJECTS GROUPED BY GRADE AND BY SEX

Groups	S.S.	df	M.S.	F
Grade Four	96.44	2	48.21	.08
Grade Six	22719.25	2	11359.63	19.63**
Boys	5926.75	2	2963.38	3.45*
Girls	9806.81	2	4903.41	12.25**

Significant at the .01 level**
Significant at the .05 level*

Data were further divided into subgroups for each of grade four girls, grade four boys, grade six girls, and grade six boys in order to determine more specifically where test differences actually occurred. An A.P.L. function was used for this purpose. Resulting data are given in Tables VIII and IX.

TABLE VIII

TEST OF SIMPLE MAIN EFFECTS OF TEST WITH SUBJECTS GROUPED AS INDICATED

Group	M.S.	F	p
Grade Four Girls	145.31	.26	.77
Grade Four Boys	8.31	.02	.98
Grade Six Girls	8177.08	14.88	.00**
Grade Six Boys	5635.93	10.26	.00**

Significant at the .01 level**

TABLE IX

SUMMARY OF NEUMAN-KEULS ANALYSIS OF DIFFERENCES BETWEEN THE MEANS OF THE GRADE SIX GROUPS

	Concrete-Picture	Concrete-Story	Picture-Story
Grade Six Girls	.01	.01	n.s.
Grade Six Boys	.05	n.s.	.05

As the data of these tables indicate, performances of neither the grade four boys nor girls were significantly affected by the mode of test presentation (concrete - picture - story). Grade six boys and grade six girls, however, did differ significantly on the three tests of induction. Differences for grade six girls occurred between the concrete and picture tests, and the concrete and story tests. Differences for the grade six boys occurred between the concrete and picture tests, and picture and story tests. A profile of these test differences is given in Figure 2.

From this figure it is apparent that both boys and girls at the grade six level performed well on the concrete tests, relative to the other tests. The boys also obtained high scores on the written test. Thus the boys have two relatively high performances as opposed to the girls who have only one. This would suggest that the boy's ability to reason inductively is more generalized.

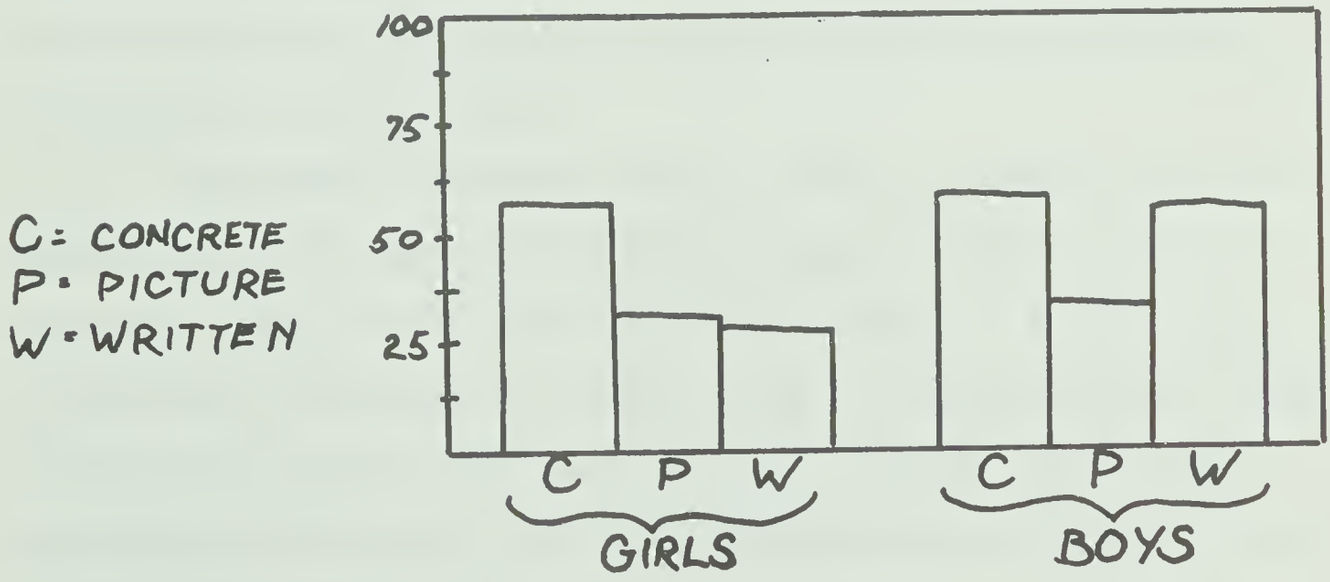

Figure 2.

Progression of Scores on Tasks by Sex (Grade Six)

Although performance on tests of the inductive cognitive operation has improved or developed over the grades (Table IV), this development has not been achieved for all the test modes. The girls made significant improvement in only the concrete mode. The boys at grade six are apparently more developed than the girls at that level in their inductive reasoning ability on material presented in the written mode. Contrary to the expectations of the writer, grade six boys did not show similar improvement in the picture test. This may be an indication that a picture mode of presentation does not intervene between the concrete and story mode in level of difficulty (at least not for grade six boys).

Interaction

Table VI indicated that there is an interaction of sex x mode and grade x mode. As stated earlier this indicates that in spite of there being no consistent effect of either sex or grade on test performances in general, performances on specific tests may be affected by the presence of these factors.

From Table V it appears that the interaction between grade and mode is due to the significantly higher scores of grade six pupils over grade four pupils on the concrete tests of induction. The sex x mode interaction is mainly due to the difference in the performances of boys and girls in grade six on the written test. This was the only test performance within grades that differed significantly between the sexes. Rawson (1969) using a test compared the performances of her male and female subjects and found that on the concrete test the grade four boys had done significantly better ($p < .001$) than the grade four girls (p.228).

The reason for this difference appearing in her study and not in this present one may be due to either test or sample bias.

Summary

Analysis of the data revealed a significant test effect for only the grade six subjects. While there was no significant difference between the performances of the grade six boys on the concrete and written tests, their performances on both these tests were significantly higher than their performance on the picture test. The grade six girls' performance on the concrete test was better than their performances on either the picture or written tests. There was no significant difference between the performances of the grade six girls on the picture and written test.

Although there was no over-all main effect due to grade or sex there was a significant grade-mode and sex-mode interaction. The source of the grade-mode interaction was the improved performances on the concrete test for grade six. The source of the sex - mode interaction was the significantly better performance of the grade six boys over the grade six girls on the written test.

III. CORRELATIONAL ANALYSIS

Three Pearson product moment correlation matrices were computed between scores on the tests of inductive operation and the variables, reading achievement, sex, chronological age, and I.Q. Intertest correlations were also computed.

Intertest Correlations

According to the data of Table X, the only significant test correlation occurred at the grade four level between tests of induction presented in picture and story modes. It would appear that these two tests have a high degree of common variance and appear to be testing relatively the same thing for grade four pupils. Conversely, performances on all the other tests for grade four and grade six appear to be dependent on different factors.

TABLE X

INTERTEST CORRELATIONS FOR GRADE FOUR AND GRADE SIX

	Concrete-Story	Concrete-Picture	Picture-Story
Grade Four	.28	.31	.88**
Grade Six	.07	-.01	.01

Significant at the .01 level**

Correlation of Reading Ability and the Three Test Modes (Table XI)

Of the three possible correlations between reading ability and the three tests of induction, only the coefficient between reading ability and the written test for the total group reached the level of significance ($p < .01$). However, at the grade four level all correlations were positive and in the right direction ($p < .18$), indicating that at this level the correlations between reading ability and the inductive tests are fairly strong.

TABLE XI

CORRELATIONS OF READING ABILITY TO TEST PERFORMANCES, AGE AND I.Q. FOR GRADE FOUR, GRADE SIX AND TOTAL SAMPLE

Group	Age	I.Q.	Concrete	Picture	Written
Grade Four	.05	.07	.24	.30	.27
Grade Six	.11	.39*	.15	-.12	.13
Total	.77**	.29*	.10	.03	.34**

Significant at the .01 level**
Significant at the .05 level*

At the grade six level there appears to be little if any relationship between reading ability and scores on the inductive operation tests.

A comparison with the Pearson product moment correlations computed by Rawson (1969) shows that for her grade four subjects she found a low correlation between reading ability and the concrete test ($r=-.10$) and a high correlation between reading ability and the written test ($r=.19$; $p<.05$).

Reading ability was significantly related to intelligence at the grade six level and for the total group. There was a high correlation (.77) between reading ability and chronological age for the total sample thus indicating that scores on the reading achievement test tended to increase with age.

Correlations of Sex and Test Mode (Table XII)

Sex correlates significantly with concrete test performances for grade four students and for the total group. This finding is similar to that of Rawson (1969), who also found a high correlation between sex and scores on the concrete test in favour of the boys at the grade four level. This suggests that the grade four boys would consistently perform better on the concrete test of inductive reasoning than the girls.

TABLE XII

CORRELATIONS OF SEX TO TEST PERFORMANCES FOR GRADE FOUR, GRADE SIX AND TOTAL SAMPLE

Subjects	Concrete	Picture	Written
Grade Four	.58**	.00	.03
Grade Six	.34	-.29	.14
Total	.47**	-.15	.09

Significant at the .01 level**

Correlations of Age, and I.Q. With the Three Test Modes (Table XIII)

At no point did chronological age correlate significantly with performances on tests of inductive reasoning. This would seem to indicate that grade (Table V) rather than age is the important variable in the increase of scores on these tests.

A very interesting contrast was the significant negative correlation ($p < .05$) between I.Q. and the concrete test at the grade

TABLE XIII

CORRELATIONS OF AGE AND I.Q. WITH THE THREE TEST MODES

Group	Variables	Concrete	Picture	Story
Grade Four	Age	.20	.00	-.03
	I.Q.	-.40*	-.08	-.02
Grade Six	Age	-.10	-.02	-.24
	I.Q.	-.39*	-.13	.32
Total	Age	.03	.02	.21
	I.Q.	.02	-.10	.22

Significant at the .05 level*

four level as compared with the significant positive correlation ($p < .05$) between I.Q. and the concrete test in grade six. A possible explanation for this can be found in the negative correlations in both grade four ($p < .05$) and grade six ($p < .01$) between age and I.Q. (Appendix E). It appears that the ability to reason inductively is a function of a particular age group. Whereas the youngest children in both grades were the more intelligent (higher I.Q. scores), the positive and negative correlations (at the grade six and four levels respectively) between I.Q. and the concrete test of inductive reasoning would seem to indicate that the older students in grade four and the younger students in grade six are doing better on the concrete tests. Both groups would be close in age and represent a "mid-age" group.

Summary

At the grade four level there was a significant ($p < .01$) correlation between the picture and written test. This was the only significant intertest correlation in either the grade four or grade six matrices. The correlation between reading ability and the written test for the total group reached the significant ($p < .01$) level. Reading ability failed to correlate significantly with any other test in any of the three matrices. Sex correlated significantly with performance on the concrete test in both the grade four ($p < .01$) and total matrices ($p < .05$). In both instances the correlation favoured the boys. The correlation between I.Q. and the concrete test changed from being significantly ($p < .05$) negative at the grade four level to being significantly ($p < .05$) positive at the grade six level.

IV. STEPWISE REGRESSION ANALYSIS USING THE INDUCTIVE TESTS AS CRITERION VARIABLES

Examination of the data in Table XIV reveals that for grade four subjects the picture and written tests of inductive reasoning were similar in terms of the amount of variance predicted by the independent variables while the concrete test of inductive reasoning appeared to be dependent on different factors. This difference is indicated by the small total variance predicted for the picture and written tests relative to the total variance predicted for the concrete test. The lower percent in both the picture and written tests is due to a similar decrease in both cases of the predicting value of the variables I.Q., sex, and age which are seen to lose from 90% to 100% of their predictive value. The most important predictor variable for these tests is reading

TABLE XIV

SUMMARY OF STEPWISE REGRESSION ANALYSIS FOR GRADE FOUR
USING INDUCTIVE TESTS AND SELECTED PREDICTOR VARIABLES

Concrete Test		Picture Test		Written Test	
Predictor Variable	% Variance Predicted	Predictor Variable	% Variance Predicted	Predictor Variable	% Variance Predicted
Sex	36.28	Reading	9.51	Reading	7.89
I.Q.	10.23	I.Q.	1.18	I.Q.	.34
Reading	6.30	Age	.41	Age	.25
Age	.81	Sex	.00*	Sex	.00
Total Variance Predicted	53.62		11.10		8.48

* This percent was established on the basis of a perfect "0" Pearson product correlation. A perfect "0" correlation cannot be handled by the MULRØ6 program which computed this regression.

ability which remains fairly constant throughout all three tests although it never predicts more than 10% of the variance. Sex appears to be the most important variable in performance in the concrete tests. This was followed in order of importance by I.Q. and reading ability. Reading ability showed a slight improvement as a predictor of performance on the picture and written tests over the concrete tests.

An analysis of the data in Table XV shows that at grade six the picture and written tests continue to be similar in terms of total variance predicted while the concrete test continues to differ on this dimension. Although variance predicted for the concrete tests by the four variables is not as large as at grade four, it is still nearly twice that of the other two tests at the grade six level. However, the comparability of the picture and written tests at grade six cannot be supported by the increase in the relative predicting power of reading ability. This is mainly because at grade six, sex and I.Q. predict nearly all of the variance for all three tests.

A comparison of the data on Tables XIV and XV reveals two main points. While the total predicted variance for the concrete test at grade four is nearly twice that found at grade six, the other two tests show very little change in terms of total predicted variance from grade to grade. A combination of sex and I.Q. appear to be the best predictors for the inductive tests at the grade six level. This is in contrast to the decrease in strength of this combination as predictors at the grade four level. Since the grade sixes performed better on the tests of inductive reasoning (Table IV), it would therefore appear that the inductive cognitive operation has developed independently of reading ability.

TABLE XV

SUMMARY OF STEPWISE REGRESSION ANALYSIS FOR GRADE SIX USING INDUCTIVE TESTS AND SELECTED PREDICTOR VARIABLES

Concrete Test		Picture Test		Written Test	
Predictor Variable	% Variance Predicted	Predictor Variable	% Variance Predicted	Predictor Variable	% Variance Predicted
I.Q.	16.28	Sex	8.25	I.Q.	10.70
Sex	8.02	I.Q.	.73	Age	1.07
Reading	1.59	Reading	.08	Sex	1.50
Age	.63	Age	.16	Reading	.01
Total Variance Predicted	26.52		9.16		13.28

Summary

A greater percent of the variance on the concrete tests than on the picture and story tests was predicted by the recognized variables of this study (sex, I.Q., reading ability, chronological age).

Whereas the total variance for the picture and story tests at both grade levels was similar, the importance of the specific predictor variables differed. Reading ability appeared to be the most important source of variance for grade four pupils while at the grade six level, sex and I.Q. appeared to contribute the major portion of variance on these tests.

V. TRANSFER FROM PICTURE TESTS TO WRITTEN TESTS

In order to overcome the objection that although picture tasks may lie between concrete and written tasks in difficulty, they still may not be suitable for teaching transfer of skills to written tasks, it was decided to include in this study stories (written tasks) based on the same content as the pictures, and stories with different content.

As a result some children (n=6) received a picture test immediately prior to a written test of identical content, while others (n=6) received a picture test prior to the written test with a different content. The problem then arose that possibly the group who received the picture with matching content might do better on the written test than those who received a picture test with non-matching content and thus contaminate the test results. Therefore an effort was made to investigate the differential transfer of inductive reasoning from picture to story when these had similar and different contents. To do so the

formula given below was used.

$$\text{Percentage of transfer } \frac{E-C}{T-C} \times 100\%$$

E Score on written test by subjects with matching picture and written content.

C Score on written test by subjects with non-matching picture and written content.

T Sum of the total possible scores on the written test.

This formula was one of four discussed by Murdock (1957). His stated definition of transfer suggests a limitation in the present application of his formula. Citing Osgood, Murdock defined transfer as ". . the effect of a preceding activity upon the learning of given task (p.313)." Although this study utilized tests rather than learning activities, the formula was used as it was suspected that there may be a learning factor involved in the test. Murdock explicitly stated four limitations which Gagne felt were inherent in the formula. Gagne felt that it might be difficult to determine "T" as it is unlikely that subjects will achieve 100% in their first attempt at task two. As task two in this study did not involve learning trials and because several pupils did achieve 100%, this limitation did not apply. He also felt that if "T" was empirically determined it could be invalid as it is not possible to be certain that the subjects are performing at their best level. This of course could be a limitation of any study. Gagne also felt that this formula might not indicate the generally accepted phenomena of transfer which sees transfer effects decreasing as training in task two progresses. As task two in this study was a single test, it was felt that "progression" was not a significant factor. Finally, Gagne realized that the lower limit for the transfer is minus

infinity. However, the data from the study indicated that this weakness of the formula would not be invoked.

Table XVI gives the raw scores for those subjects who received matching picture and written contents (P_1W_1C) and for those who received non-matching picture and written content (P_1W_2C).

TABLE XVI

SCORES FOR GRADE FOUR AND GRADE SIX PUPILS ON THE PICTURE TEST AND THE WRITTEN TEST FOR THOSE PUPILS TESTED IN THE TEST ORDERS P_1W_1C AND P_1W_2C

Group	Order	Picture Test	Written Test
Grade Four	P_1W_1C	6	6
	P_1W_2C	11	6
Grade Six	P_1W_1C	7	10
	P_1W_2C	8	15
Total	P_1W_1C	13	16
	P_1W_2C	19	21

The formula discussed earlier was applied to determine what increased transfer resulted when subjects were given a picture test immediately before a story test of matching content. Using data from grade six there was 0% transfer attributable to the preceding picture. Using data from grade four and from total subjects the transfer was -19% and -56% respectively. It was therefore concluded that within each grade level the amount of transfer to written form matched content picture test was insignificant. The high negative transfer for the

total group would seem to indicate that for some reason the presentation of the picture tests before written tests with the same content interfered with the students performance on the written task. This could be due to the influence of school instruction where succeeding tasks generally have different content. Students may have been "set" to look for different content and consequently were not fully aware of the similarity of both tasks.

VI. SUMMARY

Subjects tended to perform better on the concrete tests of inductive reasoning. At the grade six level the girls performed significantly better on the concrete tests than either the picture or written test, while the grade six boys performed significantly better on both the concrete and the story tests than they did on the picture test.

The only significant difference between sexes within grade occurred at the grade six level on the written test. The boys performed significantly better than the girls on this test. This was the source of the significant sex - mode interaction.

Significant differences between grades were found in the concrete test performances. Both cases favoured the grade sixes. This was the source of the grade - mode interaction.

The only significant intertest correlation was between the picture test and the written test at the grade four level. Reading ability correlated significantly only with the written test of induction for the total group. An interesting change from a significant negative

correlation to a significant positive correlation between I.Q. and the concrete test of inductive reasoning occurred from grades four to six. Sex was significantly related to the concrete test of inductive reasoning in both the total and grade four matrices.

Stepwise regression analysis indicated that the four predictor variables accounted for much more variance on the concrete than on the picture and written tests. Whereas reading ability was the most important source of variance on these tests at the grade four level, sex and I.Q. provided most of the variance at the grade six level.

A test for transfer revealed that there was no differential positive transfer effect due to the similarity of the content of a picture test on a directly following written test thus indicating that the experimental data were not contaminated by this aspect of the design.

The following chapter will contain a summary of the study, discussion of the hypothesis, implications of the findings and suggestions for further research.

CHAPTER V

SUMMARY, CONCLUSIONS, AND IMPLICATIONS

Piaget's research into cognitive development indicates that children pass through predictable sequential stages of intellectual development The appearance of a new cognitive operation in this development will not necessarily mean that children will be able to use this operation in all situations. Research related to Piagetian theory indicates that the mode in which material is presented can influence the effectiveness of a given cognitive operation.

Rawson (1969) had established that grade four children tended to perform better on five selected cognitive operations when tasks were presented in a concrete mode than when they were presented in a written mode. This study was concerned with the inductive cognitive operation at the grade four and the grade six levels. The general purpose of this study was to determine the relative levels of performance of this operation when tasks were presented in a concrete mode, a pictorial mode, and a written mode.

This chapter will be divided into four sections. The first two will contain a summary of the study and the findings and conclusions. Certain limitations of the study, suggestions for further research, and educational implications arising from the study will be contained in the remaining sections

I. SUMMARY

The purpose of this study was to determine if children's performance at the grade four and six levels on questions of inductive reasoning based on pictorial mode of presentation lies between their performance scores on similar questions based on concrete and written modes. Tests of the inductive cognitive operation were designed on material presented in either a concrete mode, a pictorial mode or a written mode.

The data collected were processed by a number of statistical techniques, including two by two by three analysis of variance, Pearson product moment correlations, and stepwise regression analysis. These statistical measures were applied to determine the relative performance level on the three tests (concrete, picture, and written) by boys and girls in grades four and six. It was hoped that the correlational and regression analyses would reveal relationships not apparent in the analysis of variance. In addition to scores on the three types of tests other variables considered included reading achievement, as represented by scores on the Gates-MacGinitie Reading Test, Form D, intellectual ability, as represented by achievement scores on the Lorge-Thorndike Intelligence Tests, Level 3, sex, grade, and chronological age. The findings of these analyses are contained in the next section.

II. FINDINGS AND CONCLUSIONS

The null hypotheses stated in Chapter I are restated below and data for and against the statement of each hypothesis are explained.

Null Hypothesis I

There will be no significant difference between performances on the concrete test, the picture test, and the written test for either of the following groups;

a. grade four boys
b. grade four girls
c. grade six boys
d. grade six girls

There were sixteen subjects in each of the four designated groups. Their performances on the tests of inductive reasoning were converted to per cent scores (Table IV, Chapter IV). The scores suggested a general pattern in which the subjects obtained the highest scores on the concrete test, lower scores on the picture test, and the lowest scores on the written test. However, two of the groups (grade four boys; grade six boys) performed better on the written test than on the picture test.

The data were subjected to a two by two by three analysis of variance with one factor repeated. This revealed that the mode of test did have a significant over-all effect. In view of this, the data were grouped, first by grade, then by sex, and finally into the four groups of this hypothesis and a test of simple main effects was applied using a A.P.L. function. From this it was discovered that it was only with the grade six boys and grade six girls that the mode of test was significantly affecting the pupil's performance. The application of a Newman-Keuls test to test differences between means revealed that whereas grade six boys' performances on both the concrete and written tests were both significantly better than their performance on the picture test, the grade six girls' performance on the concrete test was

significantly better than their performances on either the picture or written tests. Apparently the grade six boys are able to successfully apply their inductive cognitive operation in more presentation modes than are the grade six girls.

On the basis of these data subsections "a" and "b" of the null hypothesis are not rejected, while subsections "c" and "d" are rejected.

Data on this hypothesis do not seem to provide a clear answer as to the relative difficulty of inductive tests of cognitive operation on tasks presented pictorially in comparison with the difficulty of such tests on tasks presented in the concrete and written modes.

Raw scores (Table IV, p.54) indicate that for grade four girls and grade six girls the order of difficulty per mode was concrete - picture - story. This would seem to indicate that for these groups the pictorial mode lies between the other two. For grade four boys and grade six boys, the performance on the written task was higher than on the picture task.

Significant differences, between tasks (as indicated above) only occurred for grade six boys and girls. For the former, questions on the inductive operation presented on pictures are significantly more difficult than such questions presented on concrete objects and written stories. The fact that the sample of grade six boys in this study had significantly higher reading scores than grade six girls may have had some bearing on this result. It could also have been that the assumption that pictures lie in a continuum between concrete and abstract materials is incorrect. Grade six girls performed significantly lower on tests of written and picture tasks thus indicating

that these types of tasks seem to present similar difficulty for this group.

Null Hypothesis 2

> There will be no significant difference between the performances of grade four boys and grade four girls on:
>
> a. concrete tests
> b. picture tests
> c. written tests

No section of the null hypothesis is rejected. This conclusion will be discussed together with the conclusions for Null Hypothesis 3.

Null Hypothesis 3

> There will be no significant difference between the performances of grade six girls and grade six boys on:
>
> a. concrete tests
> b. picture tests
> c. written tests

Subsection "c" of the null hypothesis was rejected while subsections "a" and "b" were not rejected.

To arrive at the conclusions associated with Null Hypothesis 2 and Null Hypothesis 3, the data were subjected to a two by two by three factorial experiment with the last factor repeated. The second factor of this experiment was sex which is the factor discussed in these two hypotheses. The results of the analysis indicated that sex did not have a significant over-all effect on test performances. However a significant sex - mode interaction indicated that there were specific tests on which sex would have an effect. As a result data from the inductive tests were grouped to allow a test for simple main effect of sex within grades for each test. An A.P.L. function was used for this.

This analysis revealed only one significant performance difference attributable to sex. This was at the grade six level on the written test and was in favour of the boys. It was on the basis of these data that the higher performance of the boys on the written task at the grade six level may be partially attributed to their significantly higher reading ability (Table I, Chapter III). However, as the grade six pupils were significantly better readers than the grade four pupils, and yet failed to perform significantly higher than the grade four students on the written tests, it would appear that reading ability is not the only factor involved in this written test. Therefore some of the significant difference favouring the grade six boys must be due to the sex factor.

Null Hypothesis 4

> There will be no significant difference between performances of grade four girls and grade six girls on:
>
> a. concrete tests
> b. picture tests
> c. written tests

Subsection "a" of the null hypothesis was rejected while subsections "b" and "c" were not rejected. These conclusions will be discussed with the conclusions for Null Hypothesis 5.

Null Hypothesis 5

> There will be no significant difference between performances of grade four boys and grade six boys on:
>
> a. concrete tests
> b. picture tests
> c. written tests

Subsection "a" of the null hypothesis was rejected while subsections "b" and "c" were not rejected.

The statistical program used to test Hypotheses 2 and 3, was also used to test Hypotheses 4 and 5. Grade, which is the variable under consideration in these two hypotheses, was the first factor of the analysis. Although the analysis revealed that grade had no over-all effect on test performances, a significant grade - mode interaction indicated that grade was affecting the performance on specific tests. As a result data from the inductive tests were grouped to allow a test for simple main effect of grade within sexes for each test. An A.P.L. function was used for this. The results of this analysis revealed two significant differences due to grade. Both of these involved the concrete test, and both favoured the grade six subjects.

Data on Hypotheses 2 to 5 inclusive indicate that girls did not obtain significantly higher scores than the boys on the various tests of inductive reasoning. Instead, any differences which occurred tended to favour the boys. On four of the six tests (grouped by sex), boys obtained higher scores than the girls. On one test only, however, (written test at the grade six level), was the difference significant.

Data also indicate that grade six students had developed significantly in their ability to reason inductively on tasks presented in the concrete mode. Both boys and girls at the grade six level obtained significantly higher scores than their counterparts at the grade four level. The fact that no significant differences occurred between tests on picture and story tasks would seem to indicate that there exists considerable room for improvement in this type of cognitive training.

Null Hypothesis 6

There are no significant correlations between the tests of inductive operations and:

a. reading ability
b. sex
c. chronological age
d. I.Q.

Pearson product moment correlations were computed using all data, and again using data grouped by grade. To assist in the interpretation of these correlations a stepwise regression analysis was applied to the data grouped by grade. It was hoped this would reveal any important relationships not apparent in the individual correlations.

Reading ability correlated significantly with only one of the inductive tests. This correlation, significant at the .01 level, was found only in the total matrix. The high correlation found in the total matrix could be partially due to a flattening effect caused by the separation of two relatively scattered sets of correlations for each grade.

However, it should be noted that although there was no significant correlation between reading ability and performance on any inductive tests within grades, the correlations between reading ability and the inductive tests at grade four were positive and in the right direction ($p < .18$) indicating that at the grade four level there is a tendency for the better readers to score higher on the inductive reasoning tests. At the grade six level the correlations dropped significantly. This difference in the relationship between reading ability and the inductive tests in the two grades was substantiated by the stepwise regression analysis which saw reading ability being the

most accurate predictor variable for the picture and written test for grade four while at grade six it was one of the two poorest predictors for all three tests of inductive reasoning. Apparently inductive reasoning ability has been developing independently of reading ability in the subjects in this sample.

Sex correlated significantly with the concrete inductive test in both the total and grade four matrices. Although not significant at the grade six level the correlation coefficient of .34 was fairly high. In all cases the boys' performances were higher than the girls'. Apparently at both grade levels the boys will consistently score higher than the girls in a concrete inductive test. Stepwise regression analysis revealed that of 53.62% total variance on the concrete test predicted by the variable sex, age, I.Q., and reading ability, 36.28% of that variance was attributable to sex (Table XIV, Chapter IV). Sex was also a relatively good predictor of performance on the inductive tests at the grade six level (Table XV, Chapter IV).

None of the three matrices revealed a significant correlation between chronological age and any of the inductive tests. Stepwise regression analysis indicated that age played a minor role as a predictor of variance for the three inductive tests.

I.Q. correlated significantly with the concrete tests for both grade four and grade six. However, at grade four the correlation was significant in a negative direction while at grade six it was significant in a positive direction It was felt that a possible reason for this was the negative correlation of age to I.Q. in the sample. Because of this it appeared that the negative correlation at grade four was due

to the fact that the more intelligent pupils (higher I.Q. score) were also the youngest and the youngest were having difficulties with the test. By grade six, however, even the youngest children were apparently able to handle the test. Therefore it may be that I.Q. does not have a true correlation with the inductive operation until the child has reached a certain age or grade level and through the process of cognitive development is able to handle the inductive operation. This is borne out by an examination of the place of I.Q. as demonstrated by the stepwise regression analysis. Grade fours performed slightly better on concrete tests of inductive reasoning (Table IV, Chapter IV). On this test I.Q. predicted nearly ten times as much of the variance as it did on the other two tests on which they were not able to perform so well (concrete - 10.23%, picture - 1.18%, written - .34%). At the grade six level where the ability to reason inductively has improved, I.Q. becomes the leading predictor of variance on the two tests (concrete and written) which have shown the largest improvement over grade four.

On the basis of these data subsection "c" of the null hypothesis was rejected while subsections "a", "b" and "d" were not rejected.

Transfer

The question concerning the differential transfer due to a picture test preceding a story test of similar content arose from an attempt to answer the possible objection that a picture mode would be unsuitable for transferring cognitive skills to a written mode in the process of teaching. However, by introducing the picture test with matching content the question arose as to whether or not this would assist pupils on the written test thus biasing the test results. Using

the formula described in Chapter IV, it was found that rather than being helpful, the matching picture tests might have caused the pupils to score lower on the corresponding written test.

Summary

Although at the grade four level there were no significant differences in test performance attributable to mode of presentation, test performances tended to progressively decline as subjects attempted tasks presented in the concrete mode, the picture mode, and the written mode. However, differences between tests at each level were very slight

For grade six students the tests did have a significant effect on performance. The girls performance on the concrete test was significantly better than their performances on either the picture or written test. The boys had been able to successfully apply their inductive reasoning in the written test as well as in the concrete test. However even their performance on the picture test was not significantly different from that of the grade four boys. It would appear that it is possible to reason inductively on material presented in a written form without having the same ability to reason about information contained in pictures.

Although grade and sex had no significant over-all effect on test performances, these two variables did have a significant effect on specific tests. A significant difference was found between the grades for performances on the concrete test for both girls and boys. A significant difference was found between the sexes for performances on the written test at grade six.

Reading ability was more highly correlated with test performance at the grade four level than at the grade six level. However, correlations did not reach the significance level. Apparently for this sample the ability to reason inductively has developed independently of reading ability. Sex correlated strongly with the concrete test for both levels and favoured the boys in both cases. Apparently the boys will consistently outperform the girls in a concrete test of inductive reasoning. Chronological age showed no significant correlation to test performances. I.Q. correlated significantly in a negative direction at the grade four level with the concrete test yet correlated significantly in a positive direction at the grade six level with the same test. This discrepancy was felt to result from the negative correlation between I.Q. and age.

Test for transfer indicated that the presentation of a picture test with content matching that of an immediately following story test did not cause any greater transfer than when a picture with a different content was presented first. In fact it was found that pictures with matching content actually interfered with performance on the written test.

III. LIMITATIONS

Several factors which may limit the applicability of the findings became apparent while the study was being conducted.

1. Several of the subjects had been discussing the tests prior to actually taking them. Although this did not have a major impact on the results, it nonetheless would make the test situations

slightly different for these pupils. This in turn would detract slightly from the validity of the repeated measures.

2. In spite of every effort to make questions as clear as possible a few children still had difficulty understanding them. As a result, questions were modified in one or two test situations. It is possible that in so doing the experimenter gave more clues than was intended. Moreover, this unavoidable modification would make exact duplication of the study impossible.
3. The boys at grade six were significantly better readers than the grade six girls. This may have introduced some bias in the sample.

IV. SUGGESTIONS FOR FURTHER RESEARCH

Following are suggestions for further research which have arisen from this study.

1. This study could be repeated with other grade and age levels in order to gather further data on the increase of performance on inductive reasoning tests, particularly when such tests are presented on tasks in the picture and written modes since grade six pupils did not differ significantly in their performance on such tests from the grade four pupils.
2. The study could be repeated with a larger sample drawn from a larger number of schools. Hopefully this would reduce the effect of such intervening variables as discussion of tests.
3. The study could be repeated using a wider variety of picture and story tests.
4. Other cognitive operations may be tested in a similar situation as

that designed for this study.

5. In a similar type study, a greater effort may be made to study those variables which affected performance on the tests of inductive reason.
6. In this study, a series of still black and white photographs were used. A repetition of this study using line drawings, movie film or a single picture might reveal different results.
7. A training program which would allow for a contrast of the effectiveness of two or three different modes for developing the inductive cognitive operation would be of value.

V. IMPLICATIONS

The section of Chapter I dealing with the significance of this study contained the following statement.

> If it could be shown that pictorial material formed an intermediary step between concrete and abstract material then the implications for using pictorial material to develop the cognitive operation would be considerable.

On the basis of the data collected in this study it is not possible to state conclusively that performances on pictorial material lie between performances on concrete and abstract (written) material. However, the following implications for teachers can be drawn from the results of this study. These implications must be viewed in the light of limitations discussed in Chapters I and V.

1. Intelligence cannot be used as the only criterion for how well a child should be able to make inductive inferences in reading. A child needs to reach a certain age before he is able to make inductive inferences in a written situation. Apparently this age

has been reached by grade six, at which time the higher I.Q. pupils may be expected to be more successful with inductive inferences.

2. At the grade four level, teachers should not expect either sex to be more proficient in making inductive inferences in a reading situation. However, by grade six it is likely that the boys will be more proficient than the girls. This could be used to advantage in improving boys' self concept of their reading proficiency thus improving their attitude.
3. Teachers at the grade six level should be careful about using pictures to train for the inductive operation in reading as it would appear that boys at this grade level do less well with pictures than they do with material presented in a written mode. In view of the boys higher general reading ability it may be advisable to improve general reading skills if an improvement of inductive inference in a reading situation is desired.
4. At the grade four level, reading ability and performance on the written test were closely related. Moreover, performance on the picture test was slightly higher than on the written test. This would suggest that the picture mode may be a valuable additional tool for training grade four pupils in making inductive inferences.

VI. CONCLUDING STATEMENT

This study has revealed that the mode of task presentation can have a significant effect on the performance of the inductive cognitive operation. The significance of this effect becomes apparent by grade six.

This study also indicated that between grades four and six there was an increase in the ability of children to perform the inductive operation. This ability was most pronounced with tasks presented in the concrete mode and secondly with tasks presented in the written mode.

The sex factor appeared to account for most of the variance of the concrete tests and reading ability for most of the variance on the picture and written tests at the grade four level. At the grade six level, sex accounted for most of the variance on the picture test whereas I.Q. appeared to be the most important factor in determining performances on the concrete and written tests.

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APPENDIX A

TEST MATERIALS

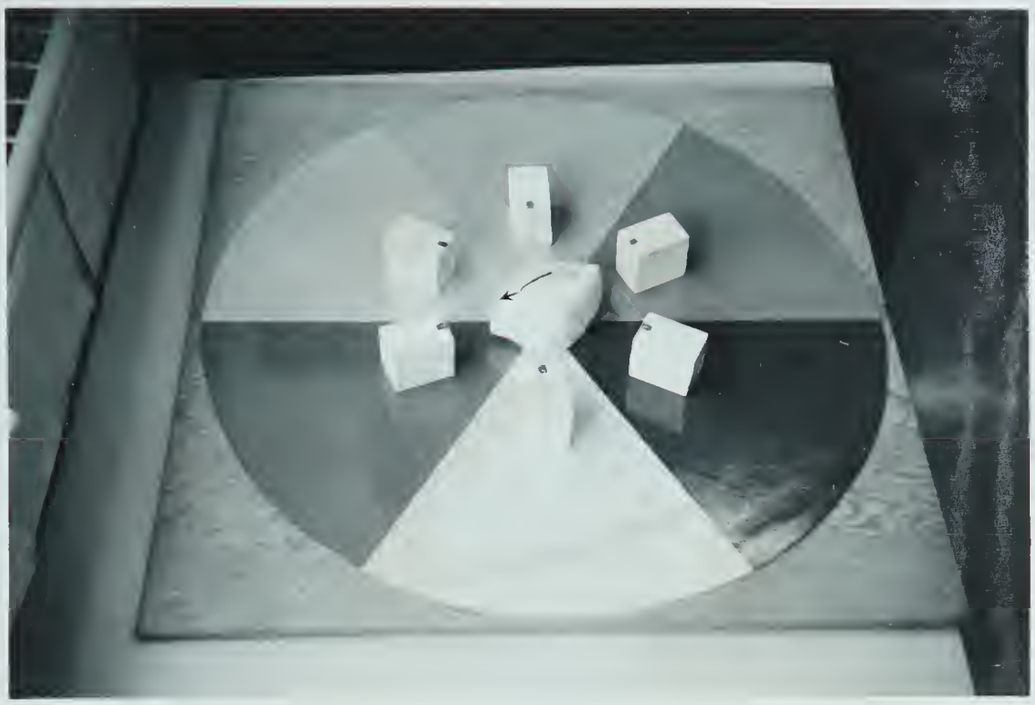

Figure 3

Apparatus For the Concrete Test

Figure 4

Apparatus For the Picture Test

Figure 5

Pictures Used in Picture Test

Written Test Materials

A. The Ball

John and Adam lived in one of the apartments in Michener Park. There were many other children who lived in the apartments. They usually had a lot of friends to play with. But today they hadn't been able to find anyone to play with. They were feeling very bored.

As they walked along in the cold spring air they tried to think of something to do. But everything they thought of needed someone else to play with them. By the time they came to the low fence running around the apartments, they couldn't think of anything else to do. They leaned against the fence and watched the cars go by. It was a very boring day.

Suddenly Adam noticed a box beside the road. He and John ran over to see what it was. When they got closer, they could see that it was an unusual box painted black. Printed on the top and two sides were the two words "Top Secret". John didn't know what they should do, but Adam said that they should open it. Carefully they put the box on the ground and Adam slowly opened the lid. The two boys peered in.

The object was packed around with bits of paper. Shifting the paper the boys saw that the object was round. For a moment the boys stood staring at the object which resembled a ball. Adam touched it and found that it was soft. John, who was feeling braver, decided to try to pick it up. He placed both his hands firmly on the sides of the object and lifted with all his strength. When he almost fell over because it was so light, Adam laughed.

John thought it was amusing too, so he laughed and threw the ball at Adam. Adam threw the ball at John, and John jumped out of the way. "Let's play tag", said John. Adam agreed and began to run, but John was too quick. When he hit Adam with the first throw, Adam laughed and scrambled after the ball. He grabbed the ball. Just as he was ready to throw it at John they heard their mother calling them for lunch.

The boys didn't want to stop but they knew they should not be late for lunch. They began to walk back to their apartment. As they walked they were playing catch and talking about what they would do after lunch. Their friends would probably be around then. John suggested they get all their friends and have a big game of tag. That would be fun. They would eat their lunches quickly.

Just as they were turning the final corner before they came to their apartment, Adam thought of something. If their mother saw the ball she would want to know where it came from and would probably take it away.

"Let's hide it", said Adam. They strolled over to their father's car. While John kept watch, Adam placed it under a cloth. He had to move a flower that his father bought for grandmother. Their pet squirrel was in the back of the car in his cage. He watched the boys suspiciously even though he was feeling sleepy. He felt sleepy because the sun had been shining in the windows all day making the car nice and warm.

After lunch the boys ran to the car. They could hardly wait. They were surprised to see that the windows of the car didn't seem as

clear as when they left for lunch. John carefully opened the door. The flower was dead and had turned black. The squirrel was lying on his back, dead. The ball was still there but it looked wet. There was stuff running off it that was smoking.

Instead of taking their toy, Adam shut the door. The two boys backed slowly away. When they were a short distance away from the car, they stopped. John and Adam still wanted to play with their ball, but they thought that something strange had happened and were afraid. Do you think that something had really happened?

B. The Cave

One summer Bob and Jack discovered a secret cave. It was on the far side of the mountain that rose hundreds of feet above the valley where they lived. People climbing the mountain had not seen the cave. It looked just like another crack in the rock wall. There were many wide cracks in the rocks made by the ice and the melting snow. They all looked much like this one. But Bob and Jack found an opening running off from the crack. They scrambled through this opening and came to a huge dark cave. The cave seemed to go on deep under the mountain.

The boys were much too frightened to explore the cave right away. They went in only a little way, just a few steps, the first day. Next day they came back and went in a little further. But they still just peered into the deep darkness of the cave and backed out again very quietly.

The third day they had a real shock. They were only a little way inside the cave when hundreds of bats flew screaming out of the

cave over their heads. Not one of the bats collided with the boys, but how they could miss them was a miracle. The air was black with bats. The noise of their screaming echoed from the walls of the cave.

Now the first time this happened it was very frightening. But the boys got used to it. Every day when they came to the cave hundreds of bats flew out over their heads. The boys began to enjoy the excitement. They would imitate the wild shrill calls of the bats and listen to the echoes from inside the cave.

Slowly now the boys began to explore the cave. A little way inside they found a tiny waterfall.

"This cave would make a good den for a wild animal", they said to each other. But then they remembered that there were no animals that lived in caves on this mountain. There were only rabbits and squirrels and chipmunks. These animals dug burrows in the ground. Besides, they lived further down the mountain where there was good food for them.

The boys pushed a little further each day into the cave. It got darker and darker as they went in. They decided to bring candles so they could see their way.

For a month the boys visited the cave every day. Every day the bats flew out over their heads. The boys waited until the bats had gone, then lit their candles and started to explore.

One day they came to the cave and shouted as usual for the bats to fly out. But nothing happened. The silence was terrible. The boys threw some stones and shouted to make a noise. All was silent and still. They waited and listened. There was no sound from the cave. They took

one step inside the opening and lit their candles. The candles went out. They lit them again. The candles sputtered and went out again. The boys turned slowly and stepped back out of the cave.

When they got out into the sunlight they sat down on the stones at the door of the cave to think. A chipmunk ran up to them. They tossed him a peanut. He stuffed it in his cheek and headed for the cave. But turned back as soon as he reached the opening and ran to the top of the rock behind the boys.

There was no sight or sound of the bats. The whole mountain was silent and still. An eagle soared in the blue sky over the valley. When the chipmunk saw the shadow of the eagle on the rocks he scurried for cover under a stone.

Was there really something strange here or were they just imagining it? That's what the boys were wondering. That was their problem as they sat on the rocks in front of the cave to think.

APPENDIX B

TEST QUESTIONS AND SCORING PROCEDURES

A. Concrete Test of Induction

Question 1. "Where do you think the spinner will stop?"

This question was repeated and the spinner rotated until the subject realized that it was stopping at a particular point.

Question 2. "What do you think is making the spinner stop where it does?"

There were four possible replies to this;

a. It stops because of the two heavy blocks.

b. It stops because of a single block. Either of these two replies moved the subject to the suitable form of question 3.

c. An irrelevant hypothesis. In this case, they were then asked to show or explain why their hypothesis was right. If they retained their irrelevant hypothesis they received no credit for question two and were finished with the concrete test. If they rejected their hypothesis in favour of a reply such as "a" or "b" they moved to the suitable form of question three. If they rejected their irrelevant hypothesis the procedure was repeated until the subject either retained an irrelevant hypothesis or accepted either "a" or "b".

d. Failure to make any hypothesis. This will end the concrete test.

Questions 3. (i) "Can you show me that the spinner always stops at these two blocks?"

(ii) "Can you show me that the spinner will always stop at this block?"

Subjects did not necessarily have to verbalize their proofs. In several cases subjects proved their point by shifting blocks and with

a shrug or glance indicated that what they had done was satisfactory proof to them.

Questions 4. (i) "Can you show me that the spinner will always stop at that block?"

(ii) "How do you know that it isn't the other heavy block? Can you show me?"

Question 5. "Can you explain why this might be happening?"

The subject needed only to state that there was something in the block.

B. Picture And Written Tests of Induction

Although the content of the answers to all but the first question was different, the questions for the picture test and the two written tests are identical.

Question 1. "Were things really different?"

An answer of "no" at this point concluded the test.

Question 2. "What do you think could have accounted for the changes?"

There were four changes to which all subjects had been directed when the picture and written tests were first presented. Their replies to Question 2 were viewed in relation of their hypothesis to a specified number of these four changes. Preferably they did so spontaneously. If not the examiner asked them: "Does your explanation account for _____?"

Answers to Question 2 took the three following general forms.

a. Correct hypothesis (one point). This was an hypothesis which could account for all four changes. The subject had to relate his

hypothesis to at least two changes before moving to Question 3.

b. An acceptable hypothesis (one point). This is an hypothesis that could not account for all four changes but would account for at least two. If the subject recognized the limitations of his hypothesis, then he was asked the question, "Can you think of an hypothesis which will account for all the changes?" If he failed to recognize the limitations inherent in his hypothesis he was asked Question 3.

c. An unacceptable hypothesis. This is an hypothesis which did not account for at least two changes. If the subject recognized at least one limitation to his hypothesis he was asked a similar question as was asked in "2b". If he did not recognize the limitations of his hypothesis the subject was asked Question 3.

Question 3. "So your explanation accounts for all the changes?"

Only those who gave reply "a", the second alternative of reply "b" or the second alternative of reply "c" (see Question 2) were asked this question. Those who gave reply "a" but had not yet expressed all the relationships were asked to do so here. Those who used the second alternative of replies "b" and "c" and who answered "yes" to this question, were asked Question 4. Those of this group who answered "no" at this point were again asked Question 2.

Question 4. "How could all this have happened?"

All that is required is that the subjects recognize that there was something in the air which could have accounted for both the picture and written tests.

APPENDIX C

LOGICAL COMPARABILITY OF TESTS OF INDUCTION

Logical Comparability of Three Test Modes

Stages of the Inductive Process	Concrete Tests	Picture and Written Tests
I. Recognition of an intervening constant	1.	1.
II. Statement of hypothesis either classificatory or propositional	2. A A A_X B_X B_X A_X	2. A A A_X B_X B_X A_X
III. Verification	3. falsification (A): (B_X A_X) 4. confirmation (A): (A_X B_X)	3. either A: (B_X A_X) or (A): (A_X B_X)
IV. Subsume evidence under a law	5. A & T B $\frac{B}{A \ \& \ T}$	4. A & T B $\frac{B}{A}$

APPENDIX D

SUBJECT PROTOCOLS

A. Protocols For Picture Tests

Grade Four Picture Test

E. Now when the boys came back from lunch do you think things were really different?

S. (Long pause).

E. What do you think?

S. Yes.

E. What do you think could have accounted for all the changes that you saw?

S. From the cold?

E. From the cold. Do you think the cold would have made the flowers die?

S. (Nod yes).

E. Could the cold have made the flower go black?

S. No.

E. No. Could the cold have killed the squirrel?

S. Yes?

E. Could the cold have made the windows all cloudy?

S. (Indicates No).

E. Can you think of something that would account for all of those changes?

S. (Long pause). I don't know.

Grade Six Picture Test

E. When they came back outside do you think things were different?

S. I don't know what you mean sort of?

E. Uh, well had there been any changes while they were in the house?

S. No.

E. So everything was exactly the same?

S. Well they don't know but they're in the house . . . cause they're . . .

E. In the house they don't know but when they came out of the house. See they put the ball in the car, and then they went into the house and when they came back to the car was anything different?

S. Yes.

E. Something had really happened, eh?

S. Yeah.

E What do you think could account for all those changes that you saw?

S. The sun?

E. The sun? Could the sun have made the flower die?

S. Yeah, the heat's too hot.

E. Could the sun have made the flower turn black?

S. Yeah, cause you need water to survive.

E. Could the sun have made the windows all whatever they were . . . streaky?

S. Well the windows were like that but you couldn't see it but when the sun shines you could see it? The reflection.

E. Okay. Could the sun have made the little animal die?

S. Well yes cause he's uh . . . . . probably no water and uh, the sun's too hot on the little animal.

E So your explanation accounts for all the changes then?

S. Yeah.

B. Protocols For Written Tests

Grade Four Written Test

E. Do you think things were really different when the boys came back?

S. Uh hum.

E. What do you think could have caused all those changes?

S. Ummmmm . . . . Ohhh . . . .

E. What do you think might have done it?

S. Ummmmm . . . . (long pause).

E. You don't want to make a guess at all?

S. Ummmm . . . maybe it was too hot?

E. If it was too hot would that account for the flowers being dead?

S. Ummm . . . No?

E. No? Could it have . . . .

S. It might have been in a dark place?

E. The flowers might have been in a dark place?

S. Uh hum.

E. If it was too hot could that have made the squirrel die?

S Umm . . . maybe?

E. Maybe? Maybe yes? Maybe no?

S. Indicates yes.

E. It could then. If it was dark . . . not dark, if it was hot could that have made the flowers turn black?

S. No.

E. No? Could it have made the window change?

S. No?

E. No? Well what do you think might have happened?

S. It might have been something to do with the ball?

E. Uh hum. I'm not sure what you mean. Could this something in the ball have killed the squirrel?

S. Yes?

E. Could it? Could something in the ball have killed the squirrel?

S. Yes?

E. So your explanation will account for all the changes?

S. Yes.

E. You think so? Could it have made the windows get all . . .

S. The smoke coming out made it all steamed up?

E. Could it have turned the flowers black do you think?

S. Uh hum.

E. Okay. What do you think might have happened?

S. The ball said "Top Secret" and the boys shouldn't have opened it. They should have just left it.

E. How do you think . . . there was something inside the ball. How do you think it could effect them?

S. It might have been something for the spraying of Top Secret?

E. Uh hum.

S. The person who left the box left?

E. And did it just stay in the ball when they put it in the car?

S. Um yes?

E. Right inside the ball?

S. Uh hum.

E. And nothing came out of the ball?

S. Oh, yes.

E. Yes, something came out.

Grade Six Written Test

E. Now when the boys came back out from lunch do you think things were really different?

S. Yes.

E. What do you think could have accounted for the change that you saw?

S. The ball.

E. The ball? Could the ball have accounted for the flower?

S. Yes.

E. Could the ball have accounted for the flowers being black do you think?

S. Yes.

E. So your explanation will account for all the changes, do you think?

S. Yes.

E. Could it account for the squirrel being dead?

S. Yes.

E. Could it account for the window being cloudy . . . foggy?

S. Yes.

E. How do you think this could have happened?

S. Well, the ball had sort of like a smoking smell and it fogged up the window and made the flowers dead and black and it mmm made the squirrel dead.

E. Okay.

APPENDIX E

CORRELATION TABLES

TABLE XVII

CORRELATIONS BETWEEN PERFORMANCES ON TESTS OF THE INDUCTIVE COGNITIVE OPERATION, READING ABILITY, INTELLIGENCE, AGE, GRADE, AND SEX USING DATA FOR THE TOTAL SAMPLE

Variable		2	3	4	5	6	7	Written Test
Sex	1	.00	.03	.02	.16	.47**	-.15	.09
Grade	2		.90**	.15	.82**	.01	.03	.31**
Age	3			-.05	.77**	.03	.02	.21
I.Q.	4				.29*	.02	-.10	.22
Reading Ability	5					.10	.03	.34**
Concrete Test	6						.15	.16
Picture Test	7							.42**

TABLE XVIII

CORRELATIONS BETWEEN PERFORMANCES ON TESTS OF THE INDUCTIVE COGNITIVE OPERATION, READING ABILITY, INTELLIGENCE, AGE, AND SEX USING DATA FOR GRADE FOUR SUBJECTS

Variable		2	3	4	5	6	Written Test
Sex	1	-.02	-.16	.04	.58**	.0	.03
Age	2		-.35*	.05	.20	.0	-.03
I.Q.	3			.07	-.40*	-.08	-.02
Reading Ability	4				.24	.30*	.27
Concrete Test	5					.31*	.28
Picture Test	6						.88**

TABLE XIX

CORRELATIONS BETWEEN PERFORMANCES ON TESTS OF THE INDUCTIVE COGNITIVE OPERATION, READING ABILITY, INTELLIGENCE, AGE, AND SEX USING DATA FOR GRADE SIX SUBJECTS

Variable		2	3	4	5	6	Written Test
Sex	1	.15	.17	.41*	.34	-.29	.14
Age	2		-.48**	.11	-.10	-.02	-.24
I.Q.	3			.39*	.39*	-.13	.32
Reading Ability	4				.15	-.12	.13
Concrete Test	5					-.01	.07
Picture Test	6						.01